THE
ENGINEERING REVIEW.

Edited by
C. EDGAR ALLEN.

Vol. XII. JANUARY, 1905. No. 1. (New Series.)

Electricity and Destructor Works.

Only a few years ago, electrical engineers, as a class, were avowedly opposed to the utilization of heat derived from the combustion of towns' refuse for the generation of electricity. At the same time, sanitary engineers found that attempts to generate steam from surplus heat militated against the complete disintegration of the refuse. That was before recent improvements in furnace construction had demonstrated the fact that perfect combustion and exceedingly high temperatures could be secured in refuse destructors. Electricians continued to maintain an attitude of scepticism, but sanitary engineers moved steadily forward. At first they were content to place small boilers in the flues for the purpose of generating steam to drive auxiliary engines, and at a later date dynamos were added for lighting the destructor works. As furnaces were further improved, steam was generated in larger boilers for pumping water and sewage and for driving crushing and mortar mixing machinery, and in 1896 the Corporation of Oldham distinguished themselves by becoming the first public body to supply electricity generated by the aid of refuse-raised steam. Other authorities followed suit, and the practice is now becoming general. Still, electrical engineers do not appear to be absolutely convinced of the desirability of combined electricity and destructor works, and for this reason we are glad to find that the whole subject has been brought before the notice of the Institution of Electrical Engineers in the exhaustive paper read last month by Mr. W. P. Adams. This contribution is of comprehensive character, and gives much detailed information that ought to be of real service to all who are interested in the profitable disposal of towns' refuse.

Steam-raising Value of Refuse.—As the author remarks, the material to be dealt with is of the most unpromising nature, one-third being incombustible and another third often consisting of water. Its composition varies very much in different localities, and a remarkable circumstance is that the refuse richest in carbon comes from the poorest districts. For instance, Mr. Vincent, the electrical engineer of Bermondsey, shows that the material collected in that borough is of unusually high calorific value, and the author cites the case of another metropolitan borough where rich refuse is obtained from a working-class district, and much poorer refuse from an adjoining district inhabited by wealthy residents.

This anomalous condition appears to be due to the improvident and thriftless habits of the working classes, who rarely sift the ashes from their fires before throwing them into the dustbin. The point is made still more clear by the following figures collated from three of the tables given by Mr. Adams in his paper:

District.	Pounds of Steam per lb. of Refuse.	B.O.T. Units per Ton of Refuse.	Value of Steam per Ton of Refuse.
			d.
Shoreditch	·8	38	40
Stepney	1·12	40	32
Fulham	1·05	52	33·4
Hackney	1·2	64	25·3
Bermondsey ...	1·2	86·5	75
Beckenham ...	·96	17	26·5
Wimbledon ..	·58	33	30

Looking at the figures in the first column, which represent averages throughout the year, we find that, with the exception of Shoreditch, the poorer localities yield refuse of comparatively high calorific value. The second column gives the average number of units obtainable per ton, if all refuse were utilized; and the third column shows the value of the steam on the basis of existing coal costs. It will be observed that the two last columns do not bear any definite relation to the calorific value of the fuel, this lack of uniformity evidently being due to the differences in the several plants, to the conditions under which they are operated, and perhaps also to the manner in which the accounts have been treated or interpreted.

Steam-raising Efficiency of Destructors.—We need not follow the author in his description of the various types of destructors, most of which have been fully described and illustrated in previous volumes of the ENGINEERING REVIEW* The features characterizing all high-class furnaces of the kind are high-temperature combustion, forced draught, and provision for drying the material before charging. With regard to forced draught, we may remark that some of the systems adopted appear to consume excessive percentages of the total steam produced. Except in specially prepared tests the actual amount of steam used is rarely, if ever, measured, and, as a general rule, probably far exceeds the estimated percentage. It should not be forgotten that the improved combustion of some classes of refuse attained by forced draught may be such as to counterbalance the additional proportion of steam consumed. The subject is one that deserves the most careful enquiry on the part of engineers, as a wasteful type of blast apparatus continually in operation may absorb a large percentage of the total power generated in the form of steam. Leakage of air through the charging, access, and clinkering doors of the furnaces, as well as through cracks in the seatings and flues, has a most important effect in diminishing the efficiency of a destructor. Badly-designed flues may also conduce to air leakage, as in other ways they reduce efficiency. It is highly desirable that the heated products of combustion should be brought into contact with the boiler at the earliest possible moment. Finally, the charging arrangements should be such as to make it easy for the attendants to keep the fires properly supplied at all times. The points here briefly mentioned may have as much influence as the calorific value of the fuel itself. Hence it follows that very little guidance can be derived from comparison of results given by different types of destructor furnaces.

The Advantages of Storage.—Owing to variations in the amount and value of the refuse collected from day to day, and to hindrances offered to collection by snow, fog, and holidays, it is certainly advisable to provide for storage of sufficient material to insure steady and continuous working. Destructor plants should be charged steadily throughout the twenty-four hours. It is not practicable to regulate the combustion of refuse to suit variations of the electrical load, the maximum variation being that about two-thirds of the cells may be used during the daytime, and the full number at night. Con-

* Vol. v., pp. 221, 397; vol. ix., p. 281.

sequently Mr. Adams advocates the use of storage batteries not only to store electricity during the day for use when the peak comes on, but in conjunction with a reversible booster to equalize the load when variations occur in the rate of steam production. With the increasing employment of direct current plant, storage batteries are becoming more and more general, and their application to combined electricity and destructor works is obviously even more desirable than to generating stations where coal-raised steam is employed.

Financial Results of Joint Undertakings.—After dealing briefly with the financial aspect of combined plants from the point of view of capital expenditure, the author passes on to consider the commercial aspect of joint schemes already in operation. At the outset he raises a plea for the careful analysis of costs of both undertakings separately, and afterwards presents some interesting statistics arranged in a form similar to that employed in connection with electricity accounts. We subjoin, in tabular form, the totals for those places where complete statistics were available, and in the third column will be found the excess of expenditure over revenue, the amounts representing the net cost of refuse disposal to the sanitary authorities. It should be mentioned that the item "Sale of Electricity" represents the credit from the electricity departments in question, the average rate being about 0.5d. per unit.

Place.	Total Cost of Refuse Disposal.	Total Destructor Revenue.	Net Cost of Refuse Disposal.
	£	£	£
Shoreditch ...	8,305	4,258	4,047
Stepney ...	7,971	2,880	5,091
Fulham ...	5,462	2,149	3,313
Hackney ...	7,300	2,470	4,830
Grays	600	268	332
Bangor... ...	602	135	467

These figures are sufficient to suggest the hope that destructor stations may eventually become self-supporting. The attainment of this very desirable consummation depends upon the more complete utilization of the refuse for power purposes and the profitable disposal of clinker and other residuals. The first of these objectives is intimately connected with the exploitation of electricity supply systems and, in a smaller degree, with the accurate measurement of, and corresponding recoupment for, steam supplied to baths, laundries, and other municipal establishments, while the second affords opportunity for enterprise on the part of the management. In any event, it must be remembered that the primary function of a destructor plant is to provide for the disposal of refuse in a sanitary and unobjectionable manner, and that the station is not established in the first instance as a commercial enterprise. Hence every penny earned is a direct saving for the ratepayers. The figures contained in the various tables and plotted in diagrams by the author may be open to criticism in some respects. That they will receive due attention in this way we have not the slightest doubt, for past experience shows that one of the first qualifications of any engineer employed in the design or manufacture of refuse destructors is thought by some people to be a natural talent for controversy. We prefer to regard the subject from a broader standpoint, believing the interests of the public and of engineers alike will be best secured by united efforts to increase the popularity and efficiency of undertakings which afford legitimate scope for municipal enterprise.

Gas-Driven Electricity Stations.

In very recent years there has been a revival of interest in the gas-engine, and much labour and ingenuity have been spent in increasing its efficiency and in developing it in every way that would make it more useful as a practical machine. Engineers for a time appear to have looked upon the steam-engine as, if not the final type of prime mover,

at least the one possible commercial type for their day, and all their energy was spent upon its improvement; but this attitude has how changed and the rapid progress in gas-engine development which has marked these later years is the outward indication of the trend of modern opinion. In certain branches of work the steam-engine can be applied with peculiar advantage, and the gas-engine cannot hope to rival it; in other branches, again, the positions are reversed, and the gas-engine is acknowledged to be superior or supreme; but apart from those distinct realms where each type holds its own, there are many occasions for the installation of prime movers where the gas-engine and the steam-engine are in keen competition for supremacy, and a very close balancing of their relative advantages is required before a decision can be made.

One branch of work to which the gas-engine adapts itself extremely well, is the driving of electric generators in central stations, and considerable attention is now being paid by engineers to the possibilities of increased economy by this application. An early difficulty was the absence of high power gas-engines, but recent developments have cleared that away, and engines of large horse-power have been installed successfully in many places. The Continental engineer, M. Witz, who has done so much valuable work on gas-engines, has recently published interesting results of very satisfactory tests of high power double-acting compound Otto gas-engines, the particular type which he expects to see most in use in the future; and nearer home, Mr. Hugh Campbell has given some interesting statistics in a paper to the Leeds Local Section of the Institution of Electrical Engineers on "Gas Engines for Central Stations."

The most interesting part of Mr. Campbell's paper is that which compares the works cost per unit sold and per unit generated at two stations in Guernsey—St. Peterport steam-driven and St. Sampson's gas-driven. The former of these was designed for lighting only, but afterwards took on a power load which was created by quarries; since then the other (gas-driven) station has been erected to take this power load only, leaving the lighting as formerly to the steam plant. The two stations are therefore part of the same system, operated by the same Company, and so situated, that the cost of carriage of coal from the coal-field to the station is the same for each. Thus, the conditions fairly allow a comparison to be made, and the figures which Mr. Campbell has obtained show every month a considerable saving in works cost per unit generated in favour of the gas-driven plant. The unit generated is taken as the safer basis of comparison, in order to eliminate the loss due to transforming and transmission; if the unit sold be taken instead, the comparison is of course still more favourable to the gas-driven station. For the month of October the works cost per unit generated is 0·346d. for the gas-driven station as against 0·513d. for the steam-driven plant. These are promising figures, and further comparisons of the two systems from other quarters should be of great interest and importance.

British Steel Trade Combinations.

At a time when the manufacturers of steel-making countries have entered into combinations for the control of their home markets and for the practice of dumping in British markets, it is but reasonable that our own steel makers should draw closer together with the object of checking wasteful and unprofitable rivalry. For some months past the steel makers of Scotland and England have had their separate organisations, which acted in concert to a limited extent. Thus, selling prices were settled after periodical meetings, but these prices related only to the respective districts of the combinations, and there was nothing to prevent mutual dumping

at prices that benefited no one but the railway companies engaged in conveying steel to and from England and Scotland. The prevailing terms precluded members of the Scotch combination from selling in Scotland or in the North of Ireland—which was included within their area—at less than the "Scotch prices," but allowed them to sell at any rates they liked in England or abroad. In the same way, members of the English Association were debarred from accepting less than "English prices" in England, while they were at liberty to quote less than Scotch rates north of the Tweed or in foreign countries. It is claimed by some makers in the Cleveland district that they are able to produce on more favourable terms than Scotch firms, those on the north-west coast and in the Midlands, but we do not believe that any appreciable difference exists. Consequently, in these days when dividends on steel shares are few and far between, it is impossible for English and Scotch firms to derive profit from underselling each other in their respective markets, especially after paying railway freights. This aspect of the question has been recognised for some time in Scotland, and quite recently the North of England steel makers have come to a similar conclusion, with the result that the English and Scotch organisations will act in unison, and undercutting will become a thing of the past. The cry has been raised already that the combined makers are really promoting a market for foreign steel, and that the first effects of their association have been the delivery of plates from New York and offers of plates from Germany. It is suggested by one writer on the subject that prices have been raised and that we are producing only half as much steel as we could produce in order that the combination may maintain an artificial minimum range of selling prices. Those who are familiar with the cost of raw materials and manufacture are quite aware that existing rates are such as to leave practically no profit for shareholders, and it is a well-known fact that steel works cannot produce up to their maximum capacity owing to the large quantities of foreign steel which are admitted free of duty under our existing fiscal policy. There is little possibility of British steel makers being able to obtain inflated prices, but by suppressing internecine war, and by joining hands with the object of stopping the waste it involves, they will be the better enabled to cope with foreign competition.

Thermodynamic Analyses and Definitions.

Professor W. McF. Orr contributes to a recent number of the *Philosophical Magazine* an interesting and thoughtful article dealing with the analyses and discussions of Clausius' theorem of irreversible cycles, which one usually finds in books and writings on thermodynamics. His aim in this article is to point out the weaknesses in the analyses by which various writers deduce this theorem, and incidentally to indicate objections to certain of their definitions of fundamental terms; and the whole article gives a very good idea of the difficulties into which one may be led in this branch of scientific theory by fixing the attention too closely on mathematical analysis and too little on the necessity for clear perception of the physical facts underlying it. We do not propose to follow here the author's discussion in its entirety, but as it is chiefly concerned with the increase of entropy resulting when a system is put through an irreversible cycle, and therefore brings back an echo of the controversy on the subject of entropy which arose some time ago, we may indicate briefly the main contentions of Professor Orr.

At the outset he shows that Planck, one of the most prominent writers on this subject, gives a very peculiar and unusual definition of "irreversibility," which raises difficulties. With him the term "*reversibel*" is confined to a pro-

cess which can not only be directly reversed, but which allows the change from the initial to the final state to be made, using appliances of any kind whatsoever, yet leaving all the materials and machines used in exactly the same condition as before their application. To a process which can be directly reversed, but does not leave the materials used in the same state as at the beginning, he applies, not the term "*reversibel*," but "*umkehrbar*." Now, the difficulty raised here is that, if this definition is interpreted literally, Planck's own proof of the theorem, that if a system undergoes an irreversible ("*irreversibel*") process the sum of the entropies is increased, breaks down, for it may involve changes in the state of outside bodies, as, *e.g.*, in volume, position, density; and therefore Professor Orr concludes that in Planck's propositions and in his definition of "reversibility," instead of the phrase "without leaving changes in other bodies," we must read "without interchanging heat with other bodies." It is in this sense that Planck actually uses his definition, and with him a process is, in fact, "*reversibel*," if the system may be passed back from the final to the initial state without exchanging heat with external bodies.

Professor Orr next, following Bertrand, shows that the ordinary definitions of "temperature," "pressure," and "entropy" are only applicable to states of equilibrium, and become meaningless in dealing with many irreversible processes, as, *e.g.*, the case of a gas rushing into a vacuum. What in such cases is the pressure of the gas, when, in fact, it may be different at each point and not the same in all directions? Kirchhoff has given a definition of "temperature" which may be applied to non-equilibrium states, but an objection to it is that it has no reference to measurements which are usually made or may practically be made, and Professor Orr therefore suggests another definition, which we need not set out here. The point to notice is that Planck applies his definition of entropy, temperature, and pressure to other states than those of equilibrium, while Professor Orr shows that the suppositions which are thereby made necessary for the proof of the theorem—that the entropy of a system *continually* increases—are not justified, and that in some parts his argument involves an absolute contradiction in terms. Professor Orr's general conclusion on this part of his discussion is in these words:—

> I submit then, following Bertrand, that no definition of entropy has yet been given (with the doubtful exception of Planck's for a perfect gas) which is applicable to any states but those of relative equilibrium, and accordingly that any statement that entropy increases should be restricted to a comparison between its values in such states.

Dealing next with the proposition known as "Clausius' Theorem" and various proofs of it which have been given, the author shows that, while it is often given in the form

$$\iint \frac{d\,H}{\theta} < 0$$

for an irreversible cycle (the double sign of integration being used to show that integration is to be performed over the whole mass as well as throughout the cycle), neither Clausius himself, nor any of the later writers, has proved this proposition. Clausius has, at the most, he contends, proved that in an irreversible cycle this integral cannot be positive and may be negative. Parker deduces the negative value in the case of irreversibility, but the grounds of his deduction are not stated with sufficient distinctness; Poincaré, Kirchhoff, and Voigt simply prove that in any cycle the integral cannot be positive, not that in an irreversible cycle it must be negative; while Buckingham states that all so-called proofs involve an unproven assumption, and he considers the theorem as a new experimental principle. Professor Orr, then, maintains that with the exception of Planck's proof, which is only valid because of the unusual definition of irreversibility, no proof, logically deduced from clearly stated premisses, has yet been given of the theorem that

in an irreversible cycle from one equilibrium state to another, the entropy of the final state is greater than that in the initial state; and, further, that it is impossible to deduce this theorem from the laws of thermodynamics in the form in which they are usually stated.

No one doubts the truth of the theorem, but in order to develop it logically we must modify the ordinary statement of the second law of thermodynamics so as to introduce an additional premiss stating explicitly a property of irreversible processes which is usually implied. Professor Orr therefore suggests a slight amendment of the Second Law, and, taking Lord Kelvin's version, "that if a system in a cycle interchange heat with external bodies it is impossible that in every interchange the system should receive heat," he proposes to add a further statement to the effect that, "if any process in the cycle is one which is actually possible with natural bodies, the system must at some stage give out heat." This is merely another mode of stating that all natural or real processes are "irreversible" in Planck's sense.

The subject here discussed is one of considerable difficulty, as the suppositions made for the purpose of mathematical analysis may easily differ widely from the actual facts. Professor Orr has very properly drawn attention to some errors of this nature, and his paper serves a useful purpose by emphasizing again the necessity in this branch of physical science for clear thinking and the danger of too much reliance on pure analysis.

A Much-needed Postal Reform.

When the preferential tariff was established in 1898 by the Canadian Government, a marked increase took place in the amount of products imported from the United Kingdom, and a further increase followed the further rebate in duty made in 1900. Under the fiscal conditions now prevailing, British manufacturers possess advantages that go a considerable way towards counterbalancing the benefits derived by their American competitors from the geographical position of the United States. In one important respect, however, our most important rival possesses an advantage which, by the shortsightedness of H.M. Postmaster-General, is denied to the industrial classes in this country. We refer to the prohibitive rates of postage on British newspapers and technical journals. It is a well-known fact that British publications, containing the advertisements which are so invaluable for the promotion of trade and commerce, are very little known in Canada, while United State papers are everywhere to be seen. The reason for this undesirable state of things is that on newspapers entering the Dominion from the United States only one-halfpenny per pound has to be paid if issued direct from the office of publication, as compared with four-pence per pound paid by publishers in the United Kingdom. Canadian importers would welcome the removal of what is virtually an export duty on home publications, and for many years past the Canadian Government has impressed upon the home authorities the urgent necessity of reform, but without effect. Finally, the Dominion Government decided to reduce the postage on Canadian papers sent to Great Britain, trusting that this good example might lead to reciprocal treatment. Consequently, newspapers are now reaching this country from Canada at one-farthing per pound, or only one-eighth of the rate charged on this side of the Atlantic.

Why is it that British publishers appear to be so indifferent to this important question? We are fully convinced that much trade, now finding its way to the United States, would come to Great Britain if the Postmaster-General would break down the tariff wall that at present limits the circulation of British journals in Canada.

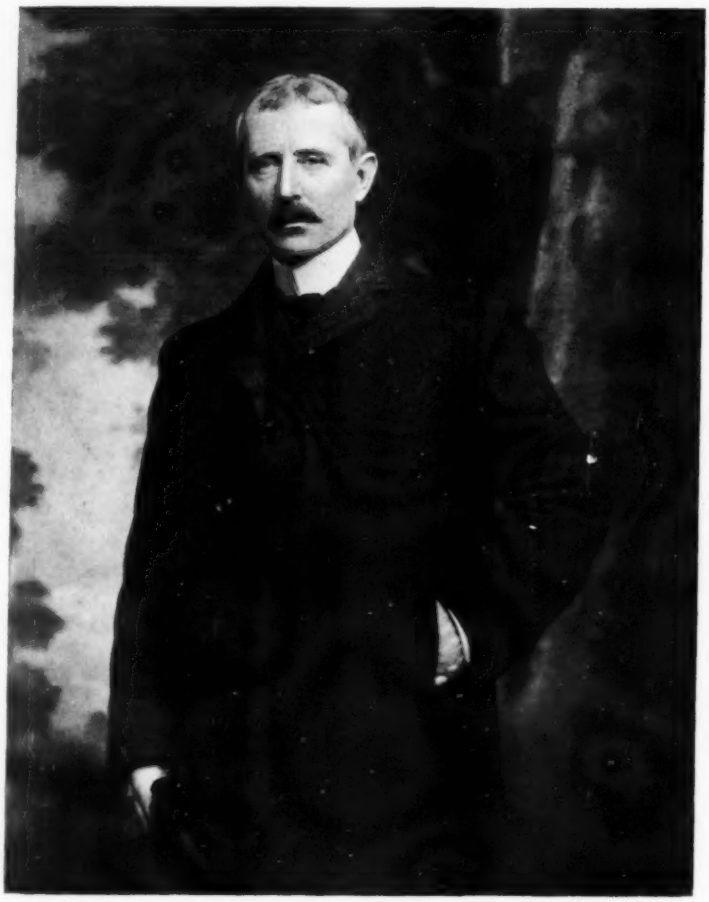


Photo by] *[Elliott & Fry.*

PROFESSOR H. S. HELE-SHAW, F.R.S.

See page 554.

The Design of Plate Girders.

By BRYSSON CUNNINGHAM, B.E., Assoc.M.Inst.C.E.

At first sight, it might appear that the design of a plate girder was one of the simplest, as it is one of the commonest, processes in the practice of civil engineering. Such an impression, however, could only be the outcome of a very limited and a very superficial acquaintance with the principles of girder design. As a matter of fact, the problem presents some of the most difficult and unsatisfactory features imaginable. It has given rise to diametrically opposite opinions and to conflicting theories, which have been the subject of frequent, and even acrimonious, debate. On these grounds it is, no doubt, that many text-book expositions are vague and indeterminate. Yet the matter is of vital importance. Plate girders are daily constructed in unlimited numbers, and erroneous principles of design must inevitably lead to one of two evils: either to an extravagant excess of material, or to an unduly low margin of strength, with its attendant risk of failure. Either alternative is greatly to be deprecated. Hence, a systematic investigation of the subject, in the light of present knowledge and experience, cannot in any sense be regarded as superfluous or inopportune. Some attempt, therefore, will be made in the present article to deal with the matter on these lines.

The mere determination of the diagrams of bending moment and of shearing stress is, of course, easy enough. No one, however, but a very young draughtsman would imagine, for a moment, that by these operations the whole of the requisite data had been obtained. The difficulties really commence at this point.

In the first place, the stresses have to be apportioned between the component parts. In parallel girders, common practice assigns the duty of shear resistance to the web, and of bending resistance to the flanges. The assumption is convenient, but it is not strictly correct. A plain plate, without flanges, if set on edge, offers undoubted and most effective resistance to bending, just as the same plate, laid flat in the manner of a web-less girder, offers certain resistance to shear. Comparatively speaking, no doubt, the latter resistance is small in girders with horizontal flanges; yet it is not without value, as is evidenced by the part it plays in girders of the hogback or curved type. The assumption, of course, is a safe one; the strength of the girder will thereby be slightly underestimated and, in this respect, no exception need be taken to it, as the margin afforded is not excessive.

But, if we agree to neglect the auxiliary offices of the flanges in regard to the shearing stress, we are still confronted by a problem of a far more perplexing nature. What are the functions of the web itself? A consideration of these functions is a source of some uncertainty, admitting of less confident assumption. A shearing stress on any rectangular element of web has been demonstrated to give rise to dual components: one, a tensile stress, acting in the direction of a diagonal, and the other, a compressive stress, acting perpendicularly thereto (Fig. 1). Obviously, the tendency of compression in a thin plate is to produce buckling. Ought not the web, then, in its subjection to a compressive stress, to be regarded as a continuous thin column, the length of which is to the depth of the girder as the diagonal of a square to its side? Such is the opinion held by some, and they calculate the web thickness on the basis of its being a columnar structure. Yet

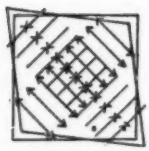


FIG. 1.

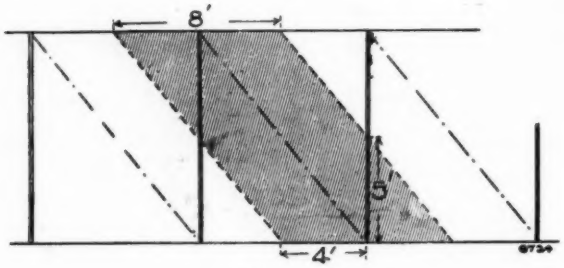


FIG 2.

the assumption is only partly defensible. However plausible it may appear, it is evidently defective in that it entirely overlooks the effect produced by the tensile component of stress. The one agency cannot be in operation without the other. Manifestly, therefore, no buckling can take place while the tension along one diagonal is counteracting the compressive effort along the other. This objection has never been satisfactorily met by the advocates of the columnar theory, for they make a claim of very questionable validity when they postulate the unimpeded action of the compressive component.

The theory, moreover, leads to unworkable results. Treated as a column simply, no ordinary plate web could possibly sustain anything like the stress which it is habitually called upon to undergo. Take a girder, for instance, of 80 ft. span, with a $\frac{3}{8}$ in. web, 8 ft. deep. According to Cooper's well-known formula, the permissible compressive stress in a thin plate web is

$$\frac{12{,}000}{1 + \frac{H^2}{3{,}000}}$$

in lbs. per square inch, where H is the ratio of length to thickness—in the present instance, $\frac{8\sqrt{2} \times 12}{\frac{3}{8}}$ The expression works out to slightly under 270 lb. per square inch. With the full depth of 8 ft., such a girder could not resist a greater total stress than $\frac{3}{8} \times 96'' \times 270$ lb. $= 4\frac{1}{3}$ tons, which, corresponding to a gross load of 240 lb. per foot run, is absurdly insufficient for a girder of that size. Even a web 1 in. thick would be insufficient for a load of 1 ton per foot run, on this system of computation, and, in actual practice, the load intensity for railway bridge girders might be expected to range between 25 and 30 cwt.

Any strict adherence to the theory is, in short, impracticable, and, recognizing this fact, its advocates fall back upon the contention that by placing stiffeners at sufficiently small intervals it is possible to reduce the virtual length of the "column," thereby increasing its resistance intensity. Thus, stiffeners may be placed, say, 24 in. apart, with the result that the columnar length becomes $24\sqrt{2}$ in., and the resistance intensity is raised to rather less than $1\frac{1}{2}$ tons, giving a total resistance of $51\frac{1}{2}$ tons and corresponding to a load of $1\frac{1}{4}$ tons per foot run. This is certainly a more reasonable figure, yet it is evident that it can only be arrived at by introducing an abnormally large number of stiffeners, whereby the weight of the girder becomes substantially increased and its cost greatly enhanced. It is not usual to place stiffeners at intervals of less than 3 ft., and to meet this arrangement it would be necessary to materially increase the thickness of the web.

The most extraordinary feature of the columnar web system, however, is its neglect of the stiffeners as functional members of the girder. Their obvious presence, to say nothing of their fre-

quent recurrence, is completely ignored in calculation. There can be no doubt on this point. Says a recent writer on the subject:—

> The stiffeners cannot fairly be regarded as taking any constructive part in the girder—that is, they are not active carriers of stress . . . They are not like the verticals in an open web girder, which have definite loads to transmit or distribute; they are put in primarily to break up certain web stresses and, by imparting a new artificial length to the directions in which these act, to enable the same web to safely carry greater stresses. Incidentally, they also considerably stiffen the girder and the flanges, act as convenient covers to the web joints and as attachments for smaller girders, etc.; but these are only subsidiary matters, and are so only because the stiffeners happen to be there. . . . They could always be done without, if weight and thickness did not matter; they are auxiliaries, making for economy and ease of manufacture, and are not first principles, such as are flanges and webs.

This anomalous attitude towards members so admirably adapted for active participation in the work of a girder is surprising, being almost inexplicable. It cannot be a matter for wonder, then, that it fails to elicit general approval; the wonder is that it claims any adherents at all.

A much more rational way of looking at the question may be found in the analogy of an ordinary framed structure.

In a framed structure, the nature of the forces at work is a matter of simple and straightforward analysis; in most cases, no doubt whatever exists as to the precise effect of any system of loading. In girder work, the span is usually divided into a number of panels, in each of which the web is made up of special tensional and compressive members, of area sufficient to deal with the shear at any point. The system of trussing, by which the compressive members are rendered most economically effective, is evidently that in which such members are as short as possible. This is best exemplified in the N or Pratt truss, where the verticals are in compression and the inclined members in tension. Here, accordingly, is indicated a method of dealing with plate girders

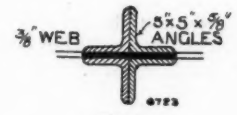


FIG. 3.

which is at once reasonable and simple. Let the girder be looked upon as a truss, divided into bays by the stiffeners, each of which constitutes a vertical compressive member or strut, the diagonally-inclined tensile stress being taken by the web in the panel between, constituting a virtual bar within the limits of the dotted lines in Fig. 2. For this duty it is eminently suited, just as it is ineffective for direct compression.

Such a conception is, of course, diametrically opposed to the interpretation placed upon the functions of stiffeners in the previous theory. Yet it is founded on common sense, and that it is closely in accordance with practical experience will be evident from the following calculations entered into in specific detail for the purpose of demonstrating the fact.

Take the case of a girder of 100 ft. span with a depth of 10 ft. Let the dead load be 10 cwt. per foot run and the live load (including allowance for impact and vibration) 1 ton per foot run, making the total load 150 tons, and the reaction at each abutment 75 tons.

The maximum shear at each end, there-

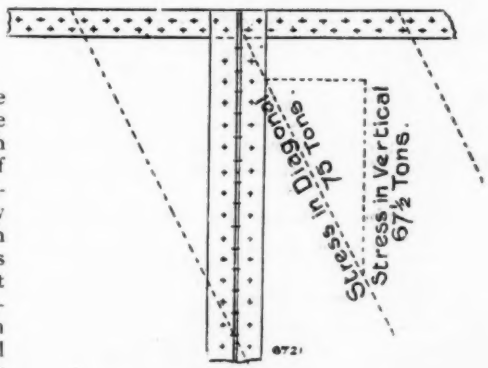


FIG. 4.

fore, is 75 tons, and, in accordance with the principles laid down, it has to be taken by the end stiffener. Assume, provisionally, a member of cruciform section, formed by four angles, each 5 in. × 5 in. × $\frac{5}{8}$ in. With a web of, say, $\frac{3}{8}$ in., the cross-section of the vertical will be as shown in Fig. 3. By Cooper's formula for railway bridge verticals undergoing dead load, the permissible unit stress in steel is

$$p = \left(14{,}000 - 80\,\frac{l}{r}\right) \text{ lb. per sq. in.}$$

where l (between centres of flanges, say, 9 ft. 6 in.) = 114 in., and r (least radius of gyration) is approximately 2.1,

$$p = 14{,}000 - 80\,\frac{114}{2{\cdot}1} \text{ lb.}$$
$$= 9{,}657 \text{ lb.} = 4{\cdot}3 \text{ tons per sq. in.}$$

For live load the formula is

$$p = 7{,}000 - 40\,\frac{l}{r}$$
$$= 2{\cdot}15 \text{ tons per sq. in.}$$

As a check, we may use an application of Gordon's formula for struts. On the ground that the fixation of the ends might possibly be slightly defective, it will be desirable to use the value of the coefficient corresponding to a rounded and a fixed end. Thus:

$$p = \frac{6{\cdot}5}{1 + \frac{1}{360} \times \left(\frac{114}{10{\cdot}4}\right)^2}$$
$$= 4{\cdot}875 \text{ tons per sq. in.}$$

This value is rather more than the 4.3 tons given by Cooper's method. The most equitable and satisfactory course will be to take a mean between the two extremes and allow a unit stress in the struts of 4.5 tons dead load and 2.25 tons for live load.

Number of inches of section required,

$$\frac{25 \text{ tons dead load}}{4{\cdot}5} = 5\tfrac{1}{2} \text{ sq. in.}$$
$$\frac{50 \text{ tons live load}}{2{\cdot}25} = 21 \text{ ,,}$$
$$26\tfrac{1}{2} \text{ sq. in.}$$

Area of selected section:—

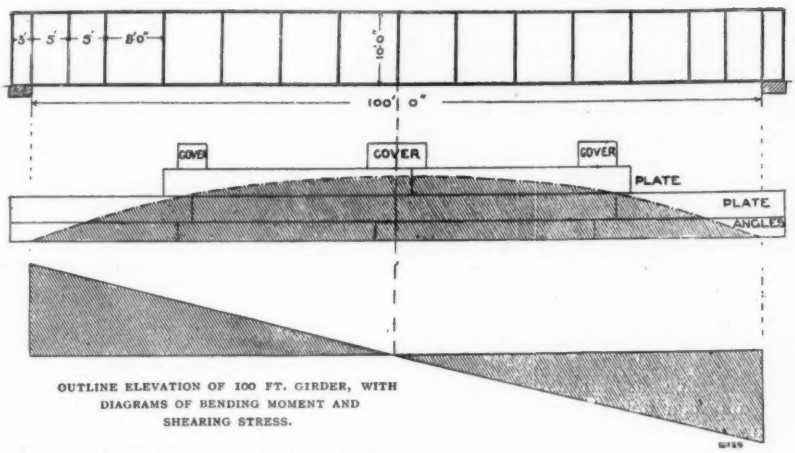
10″ × (1¼″ + ⅜″)	= 16¼ sq. in.
(10″ − 1¼″ =) 8¾″ × 1¼	= 11 ,,
	27¼ ,,

which is evidently sufficient. The stiffener might easily have been strengthened, if it had been proved necessary, by a gusset plate.

This 75 tons is, of course, the maximum shear, and the stress in the stiffeners will gradually diminish from this amount at the abutments to a minimum in the centre, so that, theoretically, the sectional area may be reduced in proportion. Practically, however, the attachment and support of the cross girders have to be considered. It is desirable to place these at distances apart not exceeding 8 ft., as by so doing it is possible and convenient to use rolled joists for the longitudinal rail bearers. Suppose, then, that the cross girders are placed 8 ft. apart, centres, and that the same dimension marks the spacing of the stiffeners. We have now to consider the tension in the web.

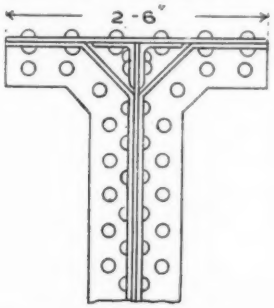
The direction of the tensile stress is along the diagonal of the bay between two stiffeners, and the stress in each diagonal is $\frac{\sqrt{(9{\cdot}5)^2 + 8^2}}{9{\cdot}5}$ times the stress in the vertical next to it, towards the centre of span. This ratio resolves itself into $\frac{13}{10}$ or 1.3 times. Now, at a distance of 8 ft. from the abutment the shearing stress is 63 tons, and therefore the stress along the diagonal of the end bay or panel is 82 tons, say. We are taking, of course, the case in which the stress is a maximum. Previously, we have tried a $\frac{3}{8}$ in. web in connection with the stiffener and found it sufficient; we will continue the experiment in regard to the imaginary diagonal.

The area necessary to take a direct tensile stress of 82 tons is $\frac{82}{6{\cdot}5}$, or 12·6 sq. in. which, divided by $\frac{3}{8}$, gives 33.6 in. as the breadth of the bar which would be required in a framed structure. There

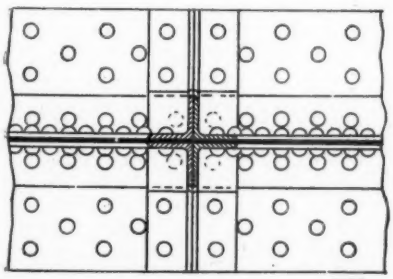


OUTLINE ELEVATION OF 100 FT. GIRDER, WITH DIAGRAMS OF BENDING MOMENT AND SHEARING STRESS.

will be found ample space for a virtual bar of these dimensions within the limits of the dotted lines in Fig. 2, which are 72 in. apart. Consequently, as far as direct tension is concerned, a $\frac{3}{8}$ in. web is satisfactory enough. The more crucial test of efficiency, however, lies in the resistance of the rivets.

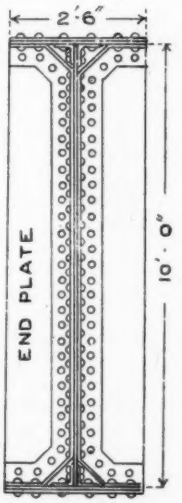


ENLARGED DETAIL OF PORTION OF STIFFENER AT ABUTMENT, SHOWING RIVETING TO WEB AND FLANGES.



DETAIL OF RIVETING AT CENTRE.

VERTICAL SECTION OF GIRDER.



Assume $\frac{7}{8}$ in. rivets, with a maximum permissible stress in shear of 4 tons and in bearing of 8 tons per square inch. The bearing value of a single rivet is $\frac{7}{8}$ in. $\times$ $\frac{3}{8}$ in. $\times$ 8 = $2\frac{5}{8}$ tons. The num-

ber of rivets required to resist a stress of 82 tons is $\frac{82}{2\frac{5}{8}} = 32$. The extreme length of intercept along the flanges available for each diagonal is 8 ft. = 96 in., necessitating a minimum pitch of 3 in. in single riveting. This would be a serviceable enough if the web were a continuous member without joints, but limits imposed by convenience and erection render it likely that there will be a separate plate for each panel. Accordingly the rivet resistance must be provided partially along the flange of the girder and partially along the stiffener. Moreover, it is desirable to bring the rivet resistance as far as practicable within approximately the same limits as the bar resistance—in other words, to concentrate the rivet resistance near the axis of stress, and to this end double riveting of the girder flange will be found necessary. The arrangement of the rivets in connection with the end diagonal, so as to meet these requirements, is indicated in Fig. 4. It will be seen that, under the particular conditions obtaining in that case, a minimum number of 29 rivets is required and is provided, whether the web plate be continuous or jointed. In the latter event, of course, a cover strip will be needed.

Now, as regards shearing. The shearing resistance of one rivet in double shear is $.6 \times 2 \times 4 = 4.8$ tons. Evidently, then, if the bearing resistance be adequate, the shearing resistance must be in excess, since the strength in regard to the latter is nearly twice as great.

Thus we have demonstrated the efficiency of a $\frac{3}{8}$ in. web, with stiffeners set at 8 ft. intervals, to deal with the shearing stress arising from the given load. This result is notable, because it represents a very much smaller quantity of metal than would be deemed necessary under the alternative or "columnar" system of calculation. Moreover, it shows that the usual limit for the spacing of stiffeners, viz., 5 ft. apart, may be exceeded to some considerable extent without detriment.

In the actual setting out of the bays or panels, one or two modifications may be made. Thus, as affording an additional margin of strength, and suggested by the consideration that 100 is not divisible by 8 in simple integers, the two bays on each side adjoining the abutments may each be made 5 ft. wide. It is possible, also, that certain special contingencies which have not been taken into account in estimating the load, might render it a judicious precaution to increase the thickness of the web by $\frac{1}{16}$ in. It is preferable, on economical grounds, that the web should be of an uniform thickness throughout; accordingly, it is not suggested that this increase should be confined to a few of the end bays as theory would indicate. These additional sources of strength, however, are matters for individual and personal discretion; they should have the effect of rendering the girder efficient beyond all question for the load contemplated.

Thus far, we have not dealt with the flanges, and we now turn our attention to them.

The maximum bending moment at the centre is $\frac{wl^2}{8} = \frac{1\frac{1}{2} \times 100^2}{8} = 1875$ foot tons. Taking the distance between centres of flanges at 9 ft. 6 in., the stress in either flange becomes $\frac{1875}{9\frac{1}{2}} = 197.4$ tons.

The permissible unit stress in steel is $6\frac{1}{2}$ tons, allowance for impact and vibration having been made in estimating the load. The nett area of flange required, therefore, is $\frac{197.4}{6\frac{1}{2}} = 30\frac{3}{8}$ sq. in.

Now, the effective area of the tension flange is less than the actual area on account of its rivet holes; this is not the case with the compression flange, but symmetry is desirable on several grounds —economic, æsthetic, and utilitarian. Accordingly, the tension flange must form the basis of calculation.

The area of two main angles, each 5 in. × 5 in. × $\frac{5}{8}$ in. is 12 sq. in., and,

deducting four rivet holes ($\frac{15}{16}$ in. each for $\frac{7}{8}$ in. rivets), the effective area is $9\frac{3}{8}$ in. Subtracting from $30\frac{1}{3}$, there remains $20\frac{3}{8}$ sq. in. to be provided by plates.

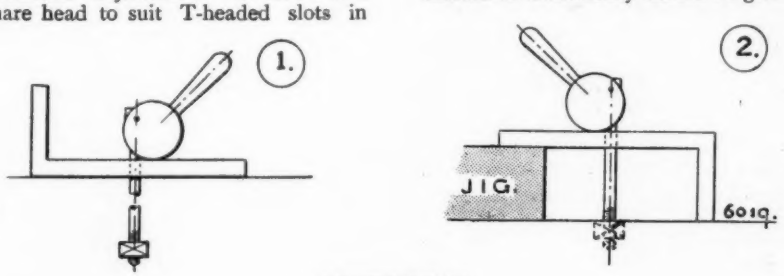
The width of the girder will be, say, $\frac{1}{10}$ span (less than this would conduce to lateral deflection), that is, 30 in. The effective width (minus six rivet holes) is $24\frac{1}{3}$ in. Therefore, the thickness of the plates should be $\frac{20\frac{3}{8}}{24\frac{1}{3}} = \frac{7}{8}$ in., at least Two $\frac{1}{2}$ in. plates may possibly be chosen This is at the centre, where the stress is a maximum. Towards the abutments one plate will suffice, as shown on the bending moment diagram. The exact extent of the second plate may easily be obtained by calculation.

The joints in the plates and angles will be arranged so as to facilitate transport to the site and to afford convenience in erection. There are, also, one or two other details which remain to be settled, but they are only of minor importance and unessential to the particular aspect of the subject under consideration, so we need not enter into them here, especially as they of a non-contentious nature. The demonstration of a simple and practical method of investigating the composition and distribution of the stresses in a plate girder marks the achievement of our immediate object, and the matter may conveniently and satisfactorily be left at this point.

One obvious corollary suggests itself, viz., that instead of drawing separate diagrams of bending moment and shearing stress, the treatment of a plate girder on the foregoing lines lends itself to analysis by a single line diagram, as in the instance of a framed structure. Such, indeed, is the case; but as uniformity of sizes is a desideratum, it is generally only necessary to determine the maximum stresses, and this may readily be done by direct calculation.

An Eccentric Clamp.

A handy tool, useful alike on the drilling, shaping, or milling machines, is the clamp shown in the illustration. It consists of a small angle-plate, the base of which is slotted, as shown, to allow a convenient adjustment. A bolt with square head to suit T-headed slots in machine table, passes through the slot, the top part of the bolt having a square block screwed on the end. This latter supports a forked lever, the jaws of which are made eccentric on both sides from the centre of the pin holding it in position, and on which it is free to move. The bolt may be made of a fixed length to accommodate the table of one particular machine, or left longer, and packings inserted between clamp and table. A fair amount of eccentricity should be given to the lever, in order to get as much variation as possible in this respect. In ordinary use it forms a stop against which jobs may be set, but by reversing the bolt it serves to hold down a "jig," or other appliance, as Fig. 2. A. L. W.



AN ECCENTRIC CLAMP.

The Design of Fly-wheels.

By A. H. GIBSON, B.Sc., Wh.Exh.

(*Continued from page* 408.)

II.

WHEN we come to design a fly-wheel for a gas-engine, we have another set of conditions to consider. In an engine using the Otto cycle, for example, in which only one impulse is given to the piston, by explosion of the gaseous mixture, in four strokes, the fly-wheel must be capable of storing up so much energy during the explosion stroke, that it may give out energy for the other three strokes of the cycle without having its velocity reduced by more than a given amount.

The problem is here, however, simplified to a certain extent by the fact that the period of time during which this surplus energy is being drawn off from the wheel extends over more than one whole stroke, and, consequently, the effect of the inertia of the moving part may be neglected. The wheel must be so designed, then, that three-fourths of the energy generated in each explosion may be absorbed in the form of kinetic energy, without exceeding the given limits of fluctuation.

Having determined the moment of inertia of the wheel, and from this its weight, the next thing is to determine its design in detail. This will, of course, depend on the purpose for which it is intended, though certain general principles are to be followed in the design of all fly-wheels.

And first of all, the stress, or load per square inch, must not exceed a certain fixed limit.

Taking the safe load on cast iron as being 12,000 lb. per sq. in., and allowing a factor of safety varying from 5 in the case of an engine driving a steady load and with a well-designed fly-wheel built in one piece, to 10 in the case of a fly-wheel for a rolling mill engine, and which is built in parts, we must so design the wheel that in no case can the stress exceed this amount in any part of the wheel.

Next consider the stress which may be brought into play in the rim of the wheel by the action of centrifugal force on the metal of the rim. If the depth of the rim is small compared with its radius, then if A is its area in square inches—if w is the weight of one cubic foot of the material in lbs.—if r is the radius of rim in feet, and if v is the linear velocity of the rim in feet per second, then considering the equilibrium of a small portion of the rim, subtending an angle θ at the centre, we get

Weight of this portion of rim =

$$w\,A\,r\,\theta \text{ lb.}$$

$\therefore$ centrifugal force on this portion =

$$w\,A\,r\,\theta \times \frac{v^2}{g\,r}$$

If Fig. 5 represent the portion of rim under consideration, we see that since the stresses exerted at the boundaries A and B of the strip are tangential to the circle there, and therefore normal to the radii $O\,A$ and $O\,B$, on joining $A\,B$ the triangle $O\,A\,B$ will serve as the perpendicular triangle of force for the forces acting on this portion of rim. So that if f is the tangential stress per square foot called into play, we have

$$\frac{A\,B}{A\,O} = \frac{w\,A\,r\,\theta\,v^2}{g\,r \times f\,A}$$

But

$$\frac{A\,B}{A\,O} = \frac{2\,A\,D}{A\,O} = 2\,\text{Sin}\frac{\theta}{2} = 2\frac{\theta}{2} \text{ (approx.)}$$

$$= \theta \text{ (approx.)}$$

$$\therefore \frac{w\,r\,\theta\,v^2}{g\,r\,f} = \theta \therefore f = \frac{w\,v^2}{g}$$

Thus the tension per square foot is quite independent of the section of the rim, and depends only on the weight per unit volume of the material and on the velocity.

If the rim be deep measured radially, the above formula only gives a moderate approximation to the real value of the stress; an accurate value as obtained by Dr. Chree's method, as given in Ewing's "Strength of Materials," being

$$f = \frac{w^2 \rho}{8g}\left\{(3+\mu)\left(r_1^2 + r_0^2 + \frac{r_1^2 r_0^2}{r^2}\right) - (1+3\mu)r^2\right\}$$

Here f = load per sq. ft. at radius r ft.
w = angular velocity of wheel.
$\mu = \frac{1}{4}$ (approx.) being Poisson's ratio for cast iron.
r_0 = inner radius of rim in feet.
r_1 = outer radius of rim in feet.
ρ = weight of 1 cubic foot of material in lbs.
g = acceleration of gravity = 32.

Now, the calculations given so far, simply apply to a revolving ring of metal, and do not take into account any stresses which may be called into play by the attachment of the arms. The main stresses due to the arms are two in number. In the first place, but for the radial restraint caused by the arms at the points of junction to the rim, the rim would expand equally radially in all directions. The arms, however, prevent this expansion to a certain extent at the points of junction, the effect being to modify the stresses in the rim as follows:

Neglecting the increase in the length of the arm due to the centrifugal action of its own weight, and assuming that the amount of its increase in length is proportional to the amount of load it supports, we get—assuming the rim to be thin in proportion to its radius—and with the same notation as used in the case of a thin rim wheel above:

Stress per square foot in rim due to centrifugal force $= \frac{w v^2}{g}$

$\therefore$ Increase in radius of rim—if

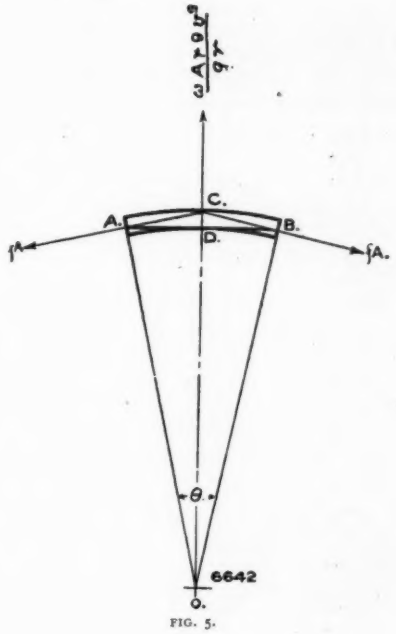


FIG. 5.

unsupported—would be $\frac{w v^2}{g E} \cdot r$ where E = modulus of elasticity of material in lbs. per square foot.

If now we take the number of arms to be n, and if the mean area of each is a square feet, then, assuming that all the load due to the centrifugal force in the rim is carried by the arms, we should get, if A is the area of the rim, load on each arm per square foot,

$$= \frac{2\pi r A w v^2}{g r n a}$$

$\therefore$ If the length of each arm is l feet, the increase in length of each arm would be

$$\frac{2\pi A w v^2}{g n a} \cdot \frac{l}{E}.$$

But at the point of junction of the rim and arm, the increase in length of the arm and the increase in radius of the wheel are identical, and therefore the amount of the centrifugal loading

taken up respectively by the tension in the rim and by the tension in the arms, will be inversely proportional to the increases in length caused in the rim and arms by the same load.

$$\therefore \left.\begin{matrix}\text{Percentage of}\\ \text{Load carried}\\ \text{by rim}\end{matrix}\right\} \div \left.\begin{matrix}\text{Percentage of}\\ \text{Load carried}\\ \text{by arms}\end{matrix}\right\} = \frac{\frac{2\pi A w v^2 \cdot l}{g n a \cdot E}}{\frac{w v^2 r}{g E}} = \frac{2\pi A l}{n a r}$$

The tangential tension per square foot in the rim will therefore be

$$\frac{w v^2}{g} \cdot \frac{2\pi A l}{2\pi A l + n a r} \text{ lb.}$$

The load on each arm will be

$$\frac{2\pi r A w v^2}{g a r n} \times \frac{n a r}{2\pi A l + n a r}$$

$$= \frac{2\pi r A w v^2}{g(2\pi A l + n a r)} \text{ lb. per sq. ft.}$$

Taking the length of each arm as being approximately equal to r, the above become:

Tangential tension in rim =

$$\frac{w v^2}{g} \cdot \frac{2\pi A}{2\pi A + n a} \text{ lb. per square foot.}$$

Load on each arm =

$$\frac{2\pi A w v^2}{g(2\pi A + n a)} \text{ lb. per sq. ft.}$$

Evidently, then, the portion of rim between any two arms may be considered as part of a continuous beam, the supporting force at the arms together with the normal loading due to centrifugal force causing a certain bending moment throughout the beam.

The given load on the arms would be produced by a normal loading on the rim of magnitude, w^1 lbs. per foot rim,

$$\text{where } w^1 = \frac{2\pi A w v^2}{g(2\pi A + n a)} \times \frac{n}{2\pi r}$$

$$= \frac{A w v^2 n}{g r (2\pi A + n a)}$$

Now the bending moment due to this loading will be greatest at the points of support, *i.e.*, at the arms, and will there have a magnitude of

$$\frac{w^1}{12}\left(\frac{2\pi r}{n}\right)^2 \text{ ft. lbs.}$$

This bending moment will tend to open the rim at its inner edge. Midway between two arms the bending moment is in the opposite direction, and of magnitude $\frac{w^1}{24}\left(\frac{2\pi r}{n}\right)^2$ ft. lbs., while at a distance $\cdot 2\left(\frac{2\pi r}{n}\right)$ from any arm, it will be zero.

If $\mathbf{1}$ be the moment of inertia of the rim in foot units, and if d is the distance from the neutral axis of the rim to its outer edge in feet, and if f is the greatest stress per square foot in the rim, due to this bending moment, then

$$f = \frac{\pi^2 A w v^2 r d a}{3\mathbf{1} n g (2\pi A + n a)} \text{ lb.}$$

In addition to this, we have the tangential tension in the rim already found, and the total maximum tension in the rim is obtained by adding these two tensions.

The effect of this bending action is greater, the thinner the rim of the wheel, and it would be advisable in any thin-rimmed wheel rotating at high velocities to strengthen the rim against bending by casting one or more internal ribs between the arms, having their deepest point midway between the arms, as shown in Fig. 6.

It will be seen, from the fact that this bending moment midway between two arms has its maximum positive value, *i.e.*, in a direction tending to open any rim joint at the outside, that to put a rim joint in that position is equivalent to making a joint in the middle of a uniformly loaded beam, and is totally opposed to every principle of design. A joint placed at the junction of the arm with the rim, is preferable, since, although the bending moment is greatest at this point, it tends to open the joint at the inside, and the common type of rim joint, consisting of two internal flanges bolted together, is better fitted to resist this. The correct position for the joint, however, when a dowel or hoop joint is used, is at the point in the rim where the bending moment is zero, as this form of fastening is not suitable for resisting any

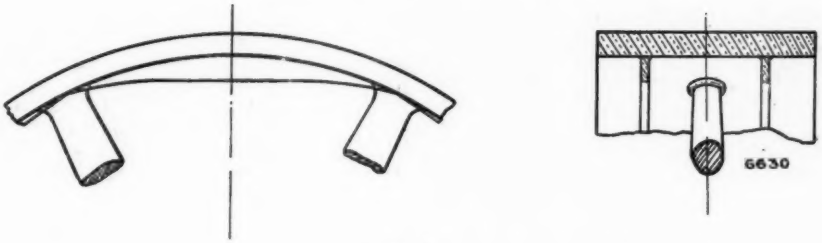


FIG. 6.

bending—*i.e.*, at a distance from any arm equal to one-fifth the distance between two arms.

In addition to the radial load on the arms, just found, causing a direct axial stress, there is a second load to be borne by the arms, at right angles to this first load, due to the turning moment which must be transmitted from the crank shaft to the fly-wheel rim in the case of a belt or rope fly-wheel. The stresses thus called into play will be perpendicular to the former stresses. If M be the maximum turning moment exerted by the engine

$$M = \frac{\text{Max. Horse Power} \times 33{,}000}{2\pi N}$$

in foot lbs., where N = number of revolutions per minute; then, if r = distance from centre of crank shaft to base of arm, and if n = number of arms, and A the area of each at the base in square feet, we have

$$M = n A r \times p$$

$$\text{or } p = \frac{M}{n A r},$$

where p = perpendicular stress per square foot.

If now f = direct stress per square foot, it may easily be shown that the maximum intensity of normal stress, due to the combination of these two perpendicular stresses =

$$\tfrac{1}{2} f + \sqrt{p^2 + \tfrac{1}{4} f^2},$$

and the arm must be so designed that this stress does not exceed the safe stress for the material of construction.

The magnitude of this tangential stress p may be very great in the case of a fly-wheel attached to a rolling engine, where the fly-wheel is almost pulled up while running at full speed.

Suppose, for example, that the fly-wheel, Fig. 7, whose weight is 36 tons, and the **1** of whose rim is 50·2 foot ton units, has its velocity changed from 100 revs. per minute to 60 revs. per minute, in 2 seconds, so that the change in angular velocity in 2 seconds is

$$(100 - 60)\ 2\pi \text{ radians per minute,}$$

$$\text{or } \frac{40}{60} \times 2\pi \text{ radians per second.}$$

But it may easily be shown that if a constant turning moment, M ft. lb., be applied to a fly-wheel whose moment of inertia in foot pound units is **1** for t seconds, then, if the change in angular velocity per second is w, we have $M t = \mathbf{1} w$. So that in this case we get,

$$\text{since } t = 2 \text{ seconds}$$

$$,, \quad \mathbf{1} = 50{\cdot}2 \text{ foot tons}$$

$$,, \quad w = \frac{4}{3}\pi$$

$$M = \frac{50{\cdot}2 \times 2240 \times 4\pi}{2 \times 3} \text{ foot lb.}$$

$$\therefore M = 236{,}000 \text{ foot lb.}$$

Since this moment must be transmitted to the rim, through the arms, the tangential stress called into play in the arms will be such as gives this moment, which is obviously much too large to be neglected.

Fig. 7 is a sketch of a wheel of excellent design, specially well fitted for the work it is intended for—that of regulating a rolling mill engine. The wheel is 18 ft. diameter—weight of rim 55,000 lb. —total weight 80,000 lb.

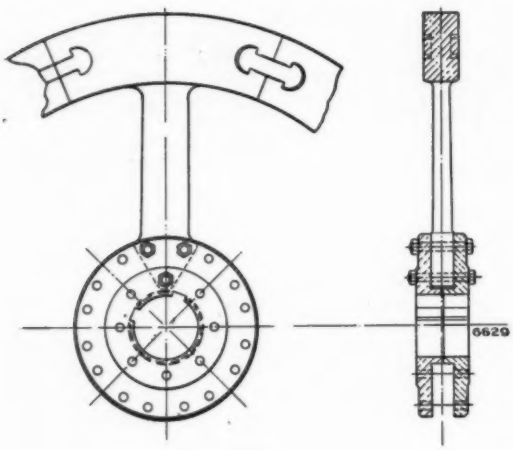


FIG. 7.

Each arm is cast in a piece with its corresponding segment, and these segments are tied together by two steel dowels, the section of each dowel being $5\frac{1}{2}$ in. $\times 2\frac{1}{2}$ in. The dowels are 14 in. long between faces, and are put into their places while hot, $\frac{8}{100}$ of an inch being allowed for shrinkage. In the case of a wheel having a moderately thin rim, the segments are fastened together by circular or oval rings, shrunk into place while hot.

The hub, as shown, is in two parts, and these halves, together with the eight arms, are fastened together by 24 fitted bolts, each $2\frac{3}{4}$ in. diameter. The wheel is attached to its shaft by two sunk keys, placed at right angles, each key being 5 in. $\times$ 4 in. The arms are particularly well fitted by their shape — oval with their long diameter perpendicular to the axis of the shaft—to resist any strains called into play by the shocks to which the wheel is subjected. This design has the advantage, moreover, that no hand work is needed in the fitting, the segments, together with the hub, being assembled together and supported horizontally on jacks, the dowels being replaced by temporary bolts. A portable radial drill then being mounted on the hub, the whole of the holes may be reamed by machine. Although in this design of wheel the rim segments are fastened together between the arms, yet, owing to the depth of the rim and the fact that the segments are cast in one piece with the arm, the bending moment midway between the arms will therefore cause only a comparatively small stress there. Preferably the joint would be made at a distance from one arm equal to $\frac{1}{5}$th the distance between the arms.

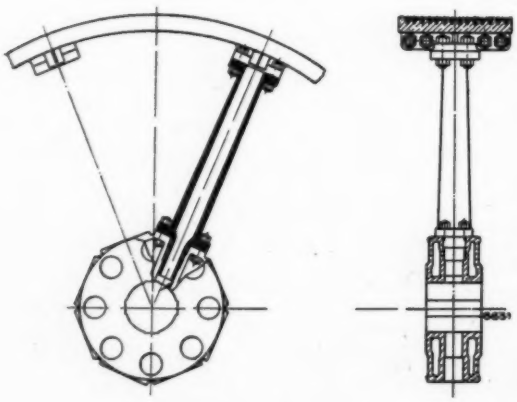


FIG. 8.

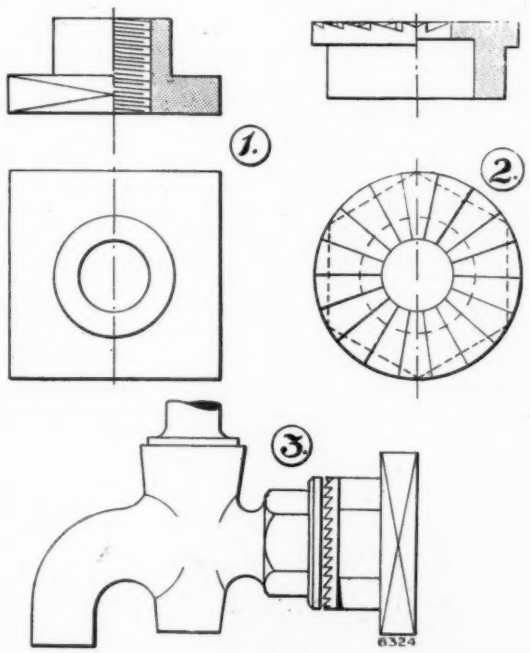
Fig. 8 shows a type of wheel very suitable for a large mill engine, and fitted for rope driving. Here the segments are fastened to each other at the arms as shown. The hub is in one piece—of cast iron—and is keyed to the shaft by four overhung keys. The sketch sufficiently elucidates the method of construction. Wheels for very high speed work have been successfully constructed of wood wrapped with steel wire, and of mild steel plates riveted together,

but such wheels are, in general, very expensive.

In the case of a cast iron or steel wheel cast in one piece, it is very advisable not to cast the hub in one solid mass, but in a series of segments, each segment being connected to its own arm. This obviates the formation of strains caused by shrinkage during cooling. In finishing the wheel, hard wood packings are forced in between the segments of the hub; the whole is turned; and steel rings are then shrunk on to each side of the hub.

A Facing Tool.

A handy tool for a pipe-fitter is shown at Figs. 1 and 2 and the method of application at Fig. 3. It consists of two parts, the first as Fig. 1, made of mild steel turned to form a bush, the other portion being left square An internal thread is cut in each one to suit the general sizes most frequently used. Fig. 2 is made of tool-steel turned to the section shown on the right, the hole an easy fit on the bush of that shown in Fig. 1. The face of the cutter is provided with radial teeth as in an ordinary face mill. The object of the tool is to remove a slight amount from the face of the tap, as shown at Fig. 3, or anything having a screwed projection and face-collar. This allows the tap or valve to be brought into the desired position. The hexagon on No. 2 provides for turning the tool, whilst the square on the bush is held by another spanner. T. H. F.



A FACING TOOL.

Bridge Design: ⌀ ⌀ ⌀

An Investigation into the Development of the Anatomy of Distinctive Types of Bridges.

By J. KERR ROBERTSON, A.M.Inst.C.E.

I.—Railway Under-bridges—Limited Head-room.

EVERY example of railway under-bridge falls into one of two classes—bridges with limited or unlimited head-room—when constructed of iron or steel, the terms through or deck bridge, while more specialized, are analogous. The various types of these classes are evolved to meet the special conditions imposed on the design by the measure of the span.

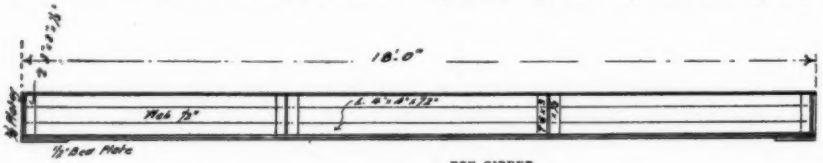
The smallest form of bridge is a culvert, the function of which is identical to that of a drain. Where the head-room is unlimited, these are usually constructed of concrete, brick, or masonry, or some combination of these; but when the space available between rail level and the clear head-room becomes less than 3 ft. 6 in., recourse must be had to some other form of construction.

The earliest examples of flat culverts, many of which are still in existence, consisted of box girders (Fig. 1) constructed of angles and plates carrying longitudinal rail bearers. This is the simplest form of girder bridge, and for small spans of 8 ft. to 10 ft. the maximum passing load is little more than the weight on the driving wheel of a locomotive or about 10 tons.

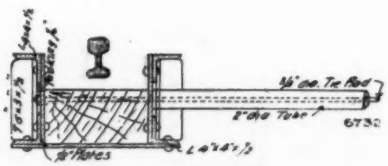
The limit of economical use of this type of bridge is reached with spans of 21 ft., or when the clearance between rail level and under side of girder approaches 1 ft. 9 in.

This design of flat culvert is seldom met with in recent examples of construction, as experience has shown that to ensure the safe and smooth passage of modern heavy rolling stock the permanent way must be constructed of a continuous and uniform type.

To meet these requirements of permanent way construction, a simple form of bridge flooring has been designed (Fig 2), consisting of building up angles and plates into troughs, which receive the sleeper and a sufficient quantity of ballast to permit of the rails being regularly packed up, and by its form giving a



BOX GIRDER.



CROSS SECTION.

FIG. 1.—UNDER-BRIDGES UP TO 21 FT. SPAN.

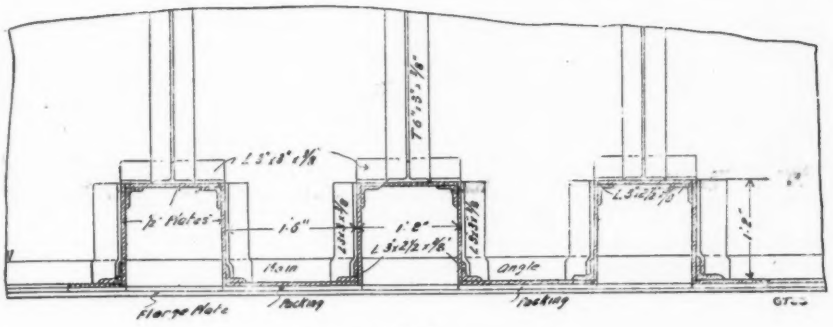


FIG. 2.
CROSS SECTION PLATE FLOORING.

greater strength and stiffness to the structure, and by reducing the volume of ballast carried effecting a material reduction in the dead load compared with the flat floors of early structures.

The apparent advantage and general use of this form of bridge flooring led to the manufacture of a great variety of ridge and furrow floorings, which now find universal adoption in the types of bridges to which their special forms may with advantage be applied.

For flat culverts up to 18 ft. span, the old form of box girder construction has been entirely superseded by the adoption of ridge and furrow flooring laid longitudinally and supporting the regular form of permanent way.

The general form of bridges of this type is shown in Fig. 3. The flooring is designed suitable for the length of the span, and may vary from 7 in to 12 in. in depth formed of plates ½ in. thick. Along the outside of the flooring a ½ in. plate 12 in. high is riveted to retain the ballast, and T bars 6 × 3 × ⅜ fastened to the ballast plate and the under side of the troughing by straps, and carrying three rows of 1½ in. diameter gas tubing forms an efficient and economical hand rail.

The space required in this type of bridge between rail level and under side of troughing varies from 1 ft. 6 in. to 2 ft. for spans up to 18 ft.

The economical range of application of longitudinally laid ridge and furrow flooring is of necessity limited to bridges of small spans, as any increase of span above 18 ft. entails the use of deep forms of flooring, extravagant at once in material and head-room.

Recognizing that the factor which causes the failure of this type of bridge to be economically applied to spans greater than 18 ft. is the measure of the span, the primary theoretical condition which must be observed in the design of bridges of greater span must be a reduc-

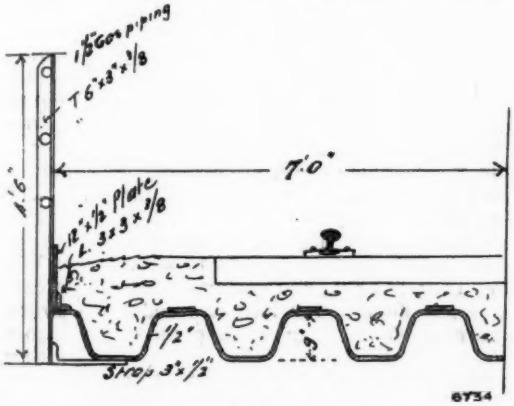
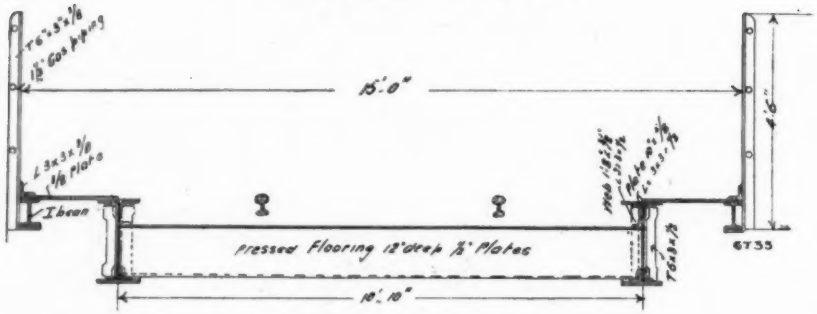
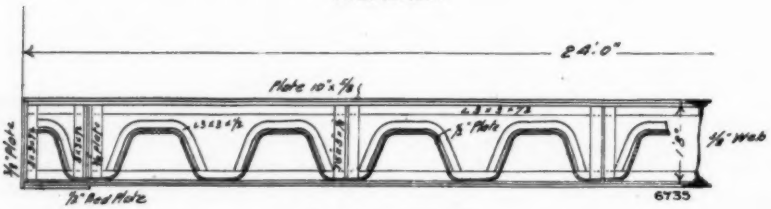


FIG. 3.
UNDER-BRIDGES UP TO 18 FT. SPAN. RIDGE AND FURROW FLOORING.
CROSS SECTION.



CROSS SECTION.



LONGITUDINAL SECTION.

FIG. 4.—UNDER-BRIDGES 18 FT. TO 25 FT. SPAN.

tion of the distance between the extreme supports of the ridge and furrow troughing measured along an axis perpendicular to the direction of corrugation.

These conditions will be complied with when the ridge and furrow troughing is laid transversely, the ends being supported by main girders resting on abutments. In this type of bridge it will be evident that the space between the rail level and the under side of troughing will remain constant through a large range of span, as the depth of the troughing is theoretically proportional to its span, which for the type of bridge under consideration will be (for bridges on straight lines) constant and determined by the load gauge for any particular line.

This design, with slight modification, is applied to bridges ranging in spans from 18 ft. to 60 ft., and entailing a loss of space between rail level and under side of girder of from 1 ft. 9 in. to 1 ft. 11 in.

For bridges of small span of this type Fig. 4 is an example of construction commonly adopted. The troughing 12 in. deep, formed of $\frac{1}{2}$ in. plates, has a span of 10 ft. 10 in., and is supported by the lower flanges of two main girders, which are of sufficient depth to serve as ballast plates. By placing the main girders so as to reduce the span of the ridge and furrow troughing to a minimum, a considerable saving in the strength of the girders can be effected, consequent to the reduction of dead load carried, as the remaining area of flooring consists of flat plates $\frac{3}{8}$ in. thick carrying no ballast and supported by light I beams to which are fixed T standards carrying the gas tubing forming the hand rail.

This design of bridge is suitable for spans for single lines of railway from 18 ft. to 25 ft. span.

When the span of this type of bridge exceeds 25 ft., the increased depth of the girders cause the footpaths to be at a higher level than the rails, which, when exaggerated by a large increase of span, forms a serious obstruction and demands a further modification of design.

In bridges spanning spaces from 25 ft.

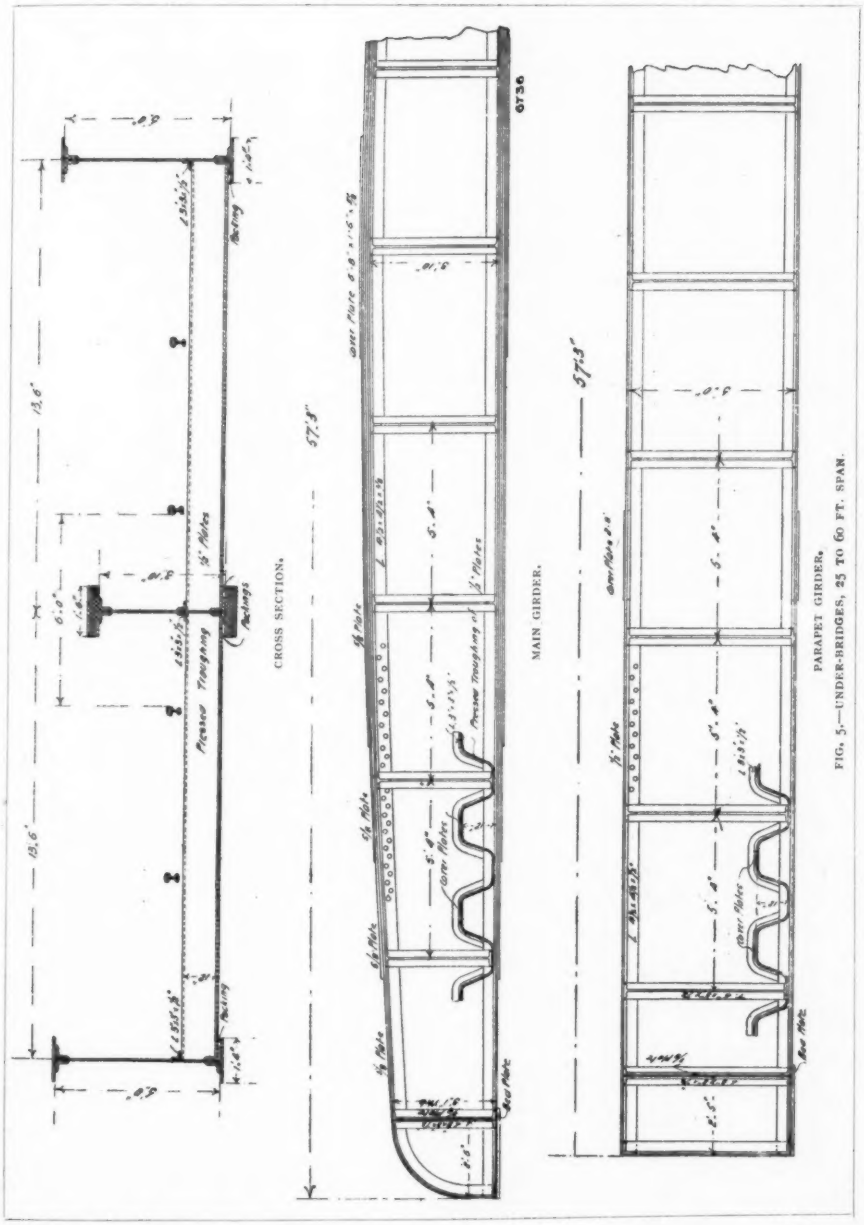


FIG. 5.—UNDER-BRIDGES, 25 TO 60 FT. SPAN.

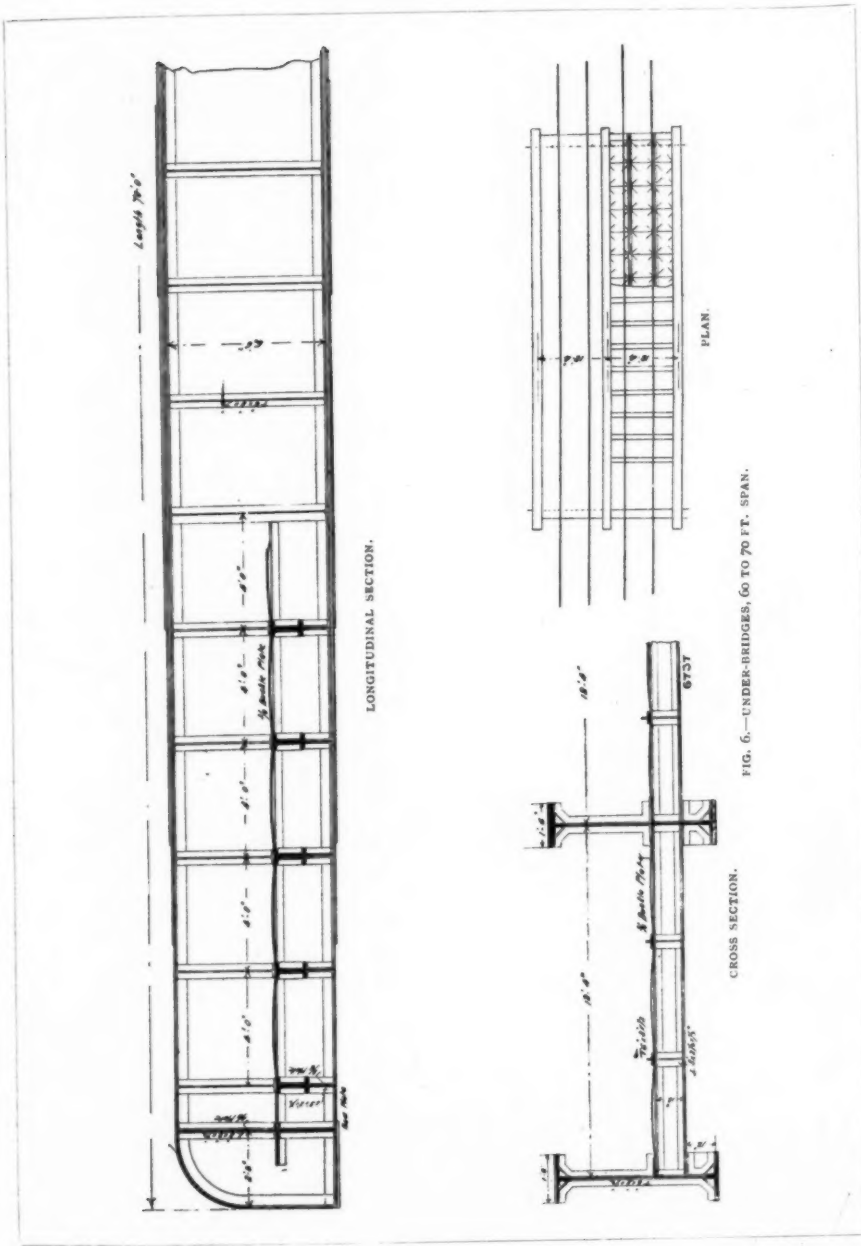


FIG. 6.—UNDER-BRIDGES, 60 TO 70 FT. SPAN.

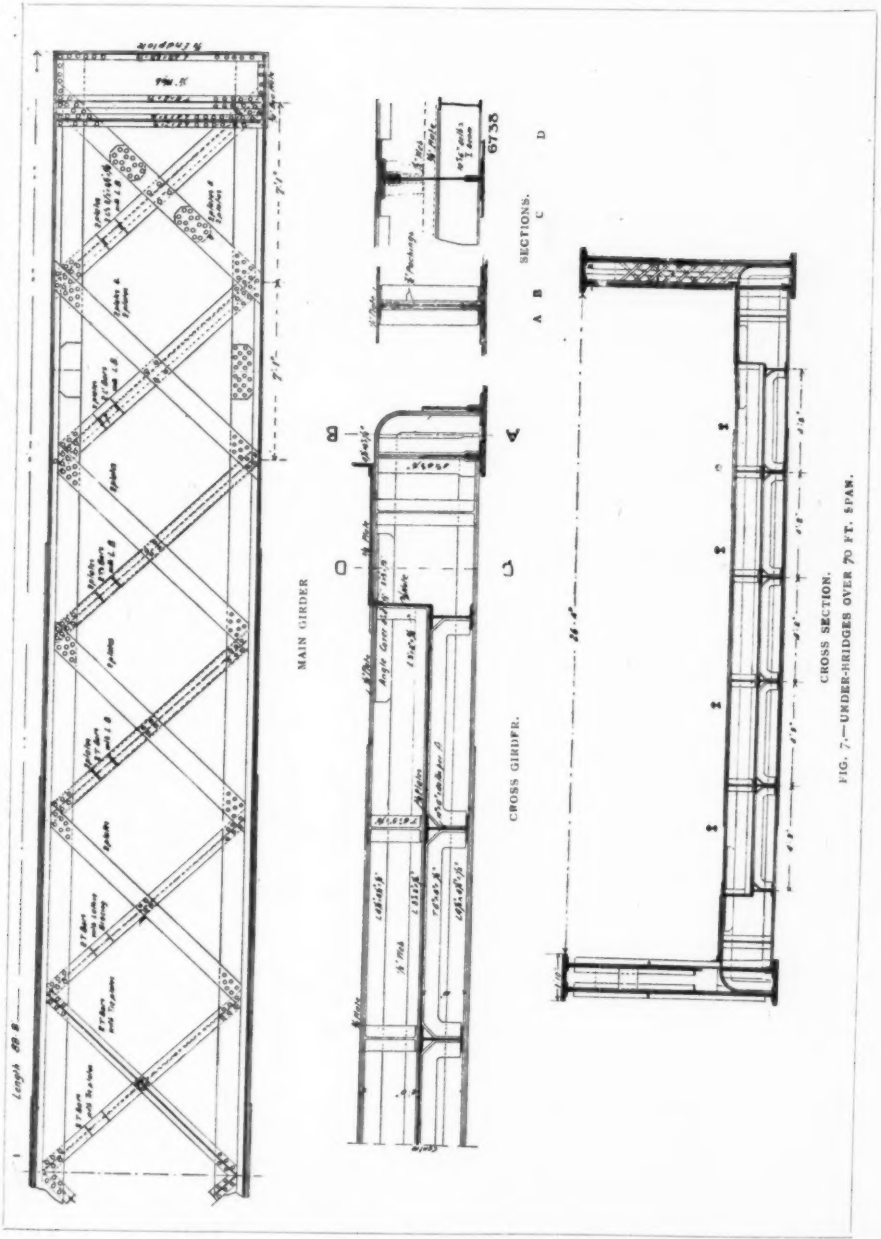


FIG. 7.—UNDER-BRIDGES OVER 70 FT. SPAN.

FIG. 8.—EXAMPLE OF BRIDGE OVER 70 FT. SPAN.

to 60 ft. the girders can economically be designed to fulfil the double function of parapet and girder. Fig. 5 shows a typical design for a bridge of this size. The girder is 57 ft. 3 in. long and 5 ft. deep, the centre girder being 3 ft. 10 in. deep. The span of the ridge and furrow troughing is 13 ft. 6 in., formed of $\frac{1}{2}$ in. plates 12 in. deep, carried on the lower boom of the girders and fixed to the web by 3 in. × 3 in. × $\frac{1}{2}$ in. angles.

For the safe working of railways, the Board of Trade recommend that

> No standing work be nearer to the side of the widest carriage in use on the line than 2 ft. 4 in. at any point between the level of 2 ft. 6 in. above the rails and the level of the upper part of the highest carriage door.

The effect of this recommendation on designs such as Fig. 5 is to restrict the depth of the centre girder to 54 in., or the limiting span to which this design is applicable is 60 ft.

In the design of bridges of from 60 ft. to 70 ft. span the consideration of the relative advantage of lattice and plate girders for reasons of economy need hardly be entered on, as the question of designing in harmony with local environment will be of greater moment than any of economy that could be effected in cost, the advantage on one side or the other of which will be dependent on the site.

The type of bridge design which meets the requirements of spans of 60 ft. to 70 ft. consists of some form of flat flooring supported by cross girders spaced 4 ft. apart and fixed to main girders. The maximum live load which cross girders are designed to support is the weight on the driving wheels of the heaviest locomotive in use on the line. This load is transmitted to the main girders as a series of concentrated loads in distinction to the more uniform distribution of the live load in bridges with ridged furrow flooring. This type of bridge is shown in Fig. 6. The length of the girder is 70 ft. and 5 ft. 6 in.

deep. To comply with the Board of Trade recommendation the cross girders are raised 12 in. from the bottom flange of the main girders, so that the top flange of the centre girder is less than 2 ft. 6 in. above rail level. The cross girders 12 in. deep are spaced 4 ft. apart and support $\frac{3}{8}$ buckle flooring. Bridges of this type are far from economical in head-room, the example shown having a space of 3 ft. 9 in. from rail to bottom of girder.

For spans exceeding 70 ft. some form of braced girder of suitable system is unquestionably the most economical form of design, both as regards cost and space between rail and bottom of girder.

The point of greatest divergence in this type of design from those previously considered is the absence of the centre girder, the cross girders being designed to carry the floor over the whole area bridged without obstruction.

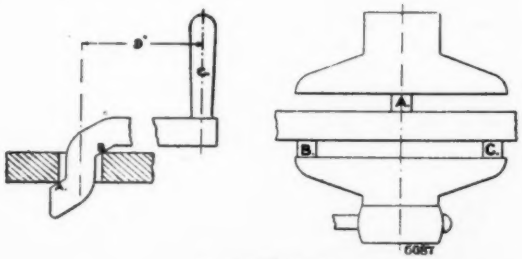
A common form of this design is shown in Fig. 7. The length of the girder is 88 ft. 8 in., 8 ft. 3 in. deep. The clear space between girders is 26 ft. 4 in., the cross girders being 2 ft. deep spaced 7 ft. 2 in. apart. Keelsons of I beams 10 in. × 6 in. × 40 lb. per ft., spaced 4 ft. 2 in. centres, span the spaces between the cross girders and support $\frac{3}{8}$ in. flat flooring plates. The flooring on either side of the bridge is raised to the level of the top of the cross girders to form a footpath. The space between the rail and under side of girder is 3 ft.

The span of this type of bridge may be increased until a certain limit is reached, after which the introduction of piers may render possible the economical continuation of this type by forming the bridge into a viaduct consisting of a series of bridges of limiting span; but where this is impracticable, the bridge passes into the class of "Bridges of Long Span."

Chamfering Tool.

A HANDY tool for taking off the burrs or countersinking drilled holes is shown at Fig. 1. It is made of cast steel, $\frac{1}{2}$ in. by $\frac{1}{4}$ in. or heavier as required. It is cranked so that it may enter the hole freely, cutting edges being filed at *A* and *B* before hardening. A handle *C* driven in a taper hole, drilled at the end or fixed crosswise on the section, completes the tool. Fig. 2: just a simple method of breaking square sections of steel, etc., by placing three packings, *A B C*, in the vice, arranged as shown. The bars are first "nicked" with a chisel, and are then easily broken.

G. H. S.



CHAMFERING TOOL.

The Construction of Towns.

By Prof. L. Cloquet (University of Ghent).

II.—The Design of a Street.

LATERAL PROFILE.—The width of a street should correspond with the importance of the traffic and not exceed the limits 2 to 300 metres. As anomalous instances, however, there is in Brussels the *Rue d'Une Personne* and in Paris the *Rue Chat qui Pêche*, which are only 1 m. 70 wide, while the Avenue du Bois de Boulogne measures 140 metres between the facades, and Washington will presently have an Avenue 300 metres wide. The most convenient widths, however, range from 8 to 10 metres for the smaller streets, from 15 to 22 for the more important, while boulevards or main thoroughfares may have 35 or more.

The relative narrowness of a street is favourable to the traffic, those of too great a width presenting a dull or monotonous appearance.

The width of a street is further dependent upon the height of the buildings.

From every house the sky overhead should be clearly visible by raising the eye through an angle not exceeding 45 deg. This hygienic requirement, only too rarely satisfied, is met by giving the streets a width at least equal to the height of the facade (Fig. 17).

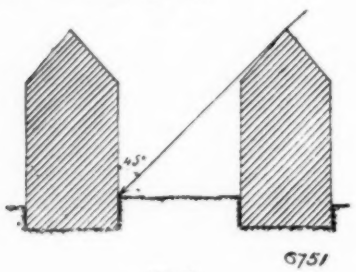


FIG. 17.

The orientation of the street must also be taken into consideration; equatorial thoroughfares are on one side almost entirely deprived of sunshine, while meridional streets receive a more abundant supply.

Consequently, authorities agree in stipulating, in the former case, for a width equal at least to twice the height of the buildings bordering such thoroughfares. On the other hand, streets which have an excessive width appear to be relatively deserted, and are not, therefore, favourable to commerce. Circumstances permitting, the best thing to do is to embellish such by the plantation of trees or the erection of monuments.

LONGITUDINAL PROFILE. — Consider the street from the point of view of its longitudinal development. This must be such as to allow, as regards the traffic, a minimum gradient, which must vary according to local circumstances, but should be kept as low as possible. From the point of view of drainage, a maximum is required, which varies according to circumstances from 5 to 1 per cent. The profile is thus generally sinuous, but maintains a mean level, which is regulated by complex elements and is higher than the mean level of the immediate ground. A superelevation of 1 metre would appear to form an excellent average. Embankments considerably augment the cost of construction of buildings erected thereon by necessitating the foundations being carried to a deeper level, while cuttings are still more unfavourable in necessitating the removal of the material and rendering proper drainage from the houses difficult to carry out.

ORIENTATION.—It is well known that the most favourable position for a house is that in which the angles of its quadrilateral are in the direction of the cardinal points. It is therefore desirable that the streets should cut each other at right angles and have a line of direction preferably from N.E. to S.W. or from N.W.

to S.E. The circumstances which regulate the street plan are, however, so complex as to render this condition difficult of realization. In the laying out of main public thoroughfares, however, consideration should be paid to the direction of the prevailing winds, as much from consideration of smoke and odours as of rain beating against the house fronts, or air currents which are set up when a high wind enfilades a thoroughfare badly arranged as to direction.

PLAN.—In plan, the design of a street depends upon many circumstances. The facilitation of traffic, which is the principal consideration, calls for straight thoroughfares, and the rectilinear plan is *a priori* the most logical, although considerations connected with the relief of the ground and those of æsthetics and hygiene sometimes counsel a departure from it.

STRAIGHT THOROUGHFARES.—The fortuitous or natural circumstances which determined the formation of ancient towns developed during a course of centuries round an unimportant centre, have given rise to a plan which, although complex, is nevertheless natural and in intimate accordance with the local topography and needs of the inhabitants.

On the other hand, towns. or portions of towns, built upon a predetermined plan are generally of the rectilinear form, and can be comprehended without difficulty. When only building and traffic requirements enter into consideration, the straight-line plan is the best, furnishing, as it does, the shortest route from one point to another, and by the quadrangular allotments permits the erection of buildings in a normal manner. Long, straight thoroughfares, however, have the drawback, from an æsthetic standpoint, of being monotonous and trying to the eye, the houses apparently merging into each other in a fugitive perspective. A distance of only three times the height of an edifice suffices to enable a spectator to obtain an advantageous view, anything further tending to spoil the effect by rendering its appearance flattened or depressed.

The Paris Opera House, viewed from the Louvre, at the end of the Avenue, appears as though it were being observed through a reversed telescope; the Rue de la Madeline suffers in the same manner. Our ancestors arranged ingenious spectacular surprises, as, for example, the sudden appearance of a majestic cathedral on rounding the corner of an eccentric street. The modern tendency with monuments or important edifices is just the opposite, which may be advantageous for the street, but decidedly detrimental to the building. As an instance may be cited the Palais de Justice at Brussels, at the end of the Rue de la Regence.

The unpleasing appearance of straight thoroughfares is accentuated in the case where the cornices of the buildings are in the same horizontal line; it is attenuated in older towns and in some parts of modern towns where the houses are detached and relieved by gables.

In general it may be laid down that a definite relation should exist between the length and breadth of a street; twenty times the breadth being the amount recommended by some authorities.

Paris, which was transformed under Napoleon III. by Baron Haussman, has been spoiled by the system of straight and lengthy thoroughfares introduced by the latter. The term *Boulevard du Spleen* has been facetiously applied to the interminable artery which pierces the town in one straight line from the Gare de L'Est to the Observatoire. The Kaiser has his Hausmann in the person of M. Kuntze, whose gigantic projects are tending to make of Berlin a grand decorative city. It is, however, being overdone, with the result that the capital of the German Empire is being rendered wearisome. London streets do not resemble those of modern Paris, with their monotonous perspective and dull facades. The older London thoroughfares preserve generally their sinuous characteristics, rectification having been carried out to reduce excessive curvature only. In the case of an exceedingly long and straight thoroughfare its aspect may be improved by interrupting its length by

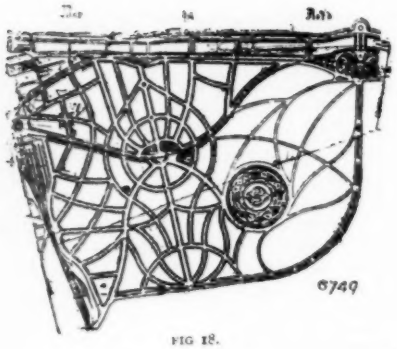


FIG 18.

widening to form a square. place, or to form a site for some building. For example, at Brussels, the church of St. Marie forms a repose for the eye between the Rue Royale and the Rue des Palais, which are in the same line. A narrow street is not necessarily ugly, some of them being, in fact, superb. Generally, the rectilinear plan is to be recommended for the monumental thoroughfares or for those in which there is a heavy traffic, and the curvilinear for streets of secondary importance, or those built in a picturesque way.

CURVED THOROUGHFARES.—"Rule of thumb," an authority has said, "has today taken the place of imagination." The bends and zigzags of many ancient streets contain unexpected and interesting surprises, and altogether they appear to be in harmony with the natural sentiment of the inhabitants. Such are the celebrated Rothentheumstrasse of Vienna, the Vieux Marché aux Vins at Strasbourg, the Corso Vittorio Emmanuel at Rome, the antique streets of Rouen, Bruges, and Ghent.

A curved plan is to be preferred to a polygonal. Curvature, or rather, concavity, assists architectural development and monumental perspective, and leads to picturesque effects, if the style of the buildings lends itself in this direction. Projecting parts of a structure—as, for example, a tower—can only be conveniently seen at a desirable distance when placed at a bend of the street. On the other hand, buildings on the convex side of a street are sacrificed. Therefore, in the design of a new town, or portion of a town, the disposition of the buildings should be such that the more important, or those which it is desired to render prominent, should have their frontage on the concave side.

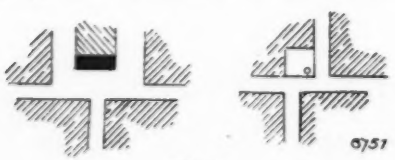


FIG. 19.

A remarkable and systematic application of the curved plan is found in the project for transforming the neighbourhood of the railway station at Blankenburgh, in Belgium (Fig. 18), by which not only will agreeable aspects be obtained, but the sea winds will be prevented from blowing directly down the public thoroughfares.

It is not necessary that both sides of a street be exactly parallel, and variety judiciously given to the width, in keeping with local and natural circumstances, is one of the best remedies to apply to faults above mentioned. Every street should have in some way an individuality or character: the grand avenue, umbrageous; the main thoroughfares, traffic; irregular promenades, places of repose and silence; commercial thoroughfares, the display of commodities; residential streets, quietude; and so on.

THE INTERSECTION OF STREETS.—An authority has shown that if one street enters another there are twelve possible cases of crossing; and where two streets intersect each other there are fifty-four cases.

As for crossings of five or six streets, or of seven, as in the case of Mansion House Place, London, these are truly formidable for the horse and foot traffic, in spite of the provision of refuges. In the Place Victor Emmanuel, at Turin, we have a circular point of convergence of twelve streets. Generally, these complex crossings are consequences of

the rectilinear plan. Although it would not appear to be so, yet it is better that two streets should not cross each other in the form of a cross, but rather in the way shown in Fig. 19. The detour thus necessitated reduces the chances of any obstruction occurring at the point of crossing.

Generally, a crossing place can be improved by erecting at the point of convergence a block of buildings, which serves to hide any irregularities of the entering thoroughfares. A crossing may be modified in another way, viz., by preserving the principal thoroughfare and suppressing or modifying the secondary streets in the manner shown in Fig. 20, which is a plan of the new quarter of the Mont des Arts, Brussels.

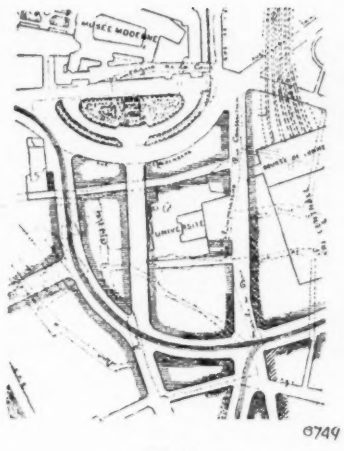
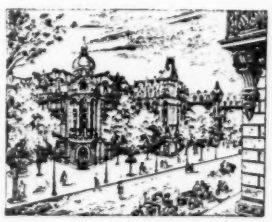


FIG. 20.

Streets intersecting at an acute angle were not so common in former times as they are to-day, nor was the multiple crossing. A thoroughfare which was too oblique was deviated to enter its artery almost at right angles. Nothing was thought of removing a portion of a street to improve the perspective.

FORM IN RELIEF.—Considered in vertical plan, the axis of a thoroughfare can be either rectilinear or curved; if the latter, it may be either concave or convex. A concave form is very agreeable; it is that of a valley, which, as is well known, is the great resource of the designers of promenades and parks. During the day such a street displays to the eye a well-developed and long perspective, full of grandeur and not monotonous, with supple and generous lines. At night the general effect of the street lamps is that of a festival illumination, and evokes the aspect of a suspended garland. This is the charm of the Avenue des Champs Elysées at Paris, and of the Boulevard de L'Observatoire, Brussels. But the convex form is most displeasing. Nothing is more ugly than a street the profile of which resembles a donkey's back. This bad effect is accentuated by the disappearance to view of the buildings, vehicles, and pedestrians behind the hump. The fault is worst when the street is straight. It can, however, be ameliorated by a vertical interruption, as in the case of a rectilinear alignment, reducing the fault of a curve of excessive length.

Irregular disposition in the alignment of the facades created by fortuit-



6750.

FIG. 21.

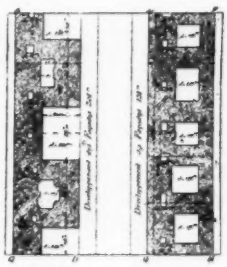


FIG. 22.

ous circumstances or careless regard of our predecessors may give an aspect of disorder to the street, and to such an extent as to destroy the picturesque element.

If it is wide, a remedy may be found by planting rows of trees.

DISCONTINUOUS ALIGNMENT. — In presence of never varying, monotonous, flat facades, the Parisians have studied new arrangements, one of which is shown in Fig. 22. Here the facade is broken by alternations of house frontages and grilled enclosures.

In another arrangement, the houses, instead of having their frontages in a direction parallel to the axis of the street are constructed obliquely, being separated from each other by triangular-shaped gardens (Fig. 21).

It must be recognized, however, that such geometric developments are inferior in charm to designs which have been naturally evolved.

BOOKS RECEIVED.

Who's Who, 1905. (London: A. & C. Black, Soho Square.) 7*s.* 6*d.* net.

Who's Who Year Book, 1905. London: A. & C Black, Soho Square.) 1*s.* net.

Englishwoman's Year Book and Directory. By Emily Janes (London: A. & C. Black, Soho Square.) 2*s.* 6*d.* net.

Model Steam Turbines: How to Design and Build Them. By H. H. Harrison. (London: Percival Marshall & Co., 26-29, Poppin's Court, Fleet Street.) 6*d.* net.

A Handbook of Chemical Engineering: Vols. I. and II. By Geo. E. Davis. (Manchester: Davis Bros., 32 Blackfriars Street). £2 2*s.*

The 'Mechanical World' Pocket Diary and Year Book for 1905. (Manchester: Emmott & Co., Ltd., New Bridge Street.) 6*d.* net.

The Practical Electrician's Pocket Book, 1905. (London: S. Rentell & Co., Ltd., 36, Maiden Lane, Strand, W.C.) 6*d.* net.

The 'Practical Engineer' Electrical Pocket Book and Diary, 1905. (Manchester: Technical Publishing Co., Ltd., 287, Deansgate.) Price, 1*s.* 6*d.* net.

The 'Practical Engineer' Pocket Book, 1905. (Manchester: Technical Publishing Co., Ltd., 287, Deansgate.) 1*s.* 6*d.* net.

Private House Electric Lighting. By Fred. H. Taylor, A.M.I.E.E. (London: Percival Marshall & Co., Poppin's Court, Fleet Street, E.C.) 1*s.* net.

Small Electrical Measuring Instruments. (London: Percival Marshall & Co., Poppin's Court, Fleet Street, E.C.) 6*d.* net.

The A. B. C. of the Differential Calculus. By Wm. D. Wansbrough. (Manchester: Technical Publishing Co., Ltd., 287, Deansgate.) 3*s.* net.

The Comparative Efficiency of English and Foreign Labour. By Lord Brassey, K.C.B., D.C.L. Address to the Manchester Chamber of Commerce. (London: Longmans, Green & Co., 39, Paternoster Row.) 6*d.* net.

Petrol Motors and Motor Cars. By T. Hyler White, A.M.I.M.E. (London: Longmans, Green & Co., 39, Paternoster Row.) 4*s.* 6*d.* net.

Modern Electric Practice: Vol. V. Magnus Maclean, M.A., D.Sc. (London: Gresham Publishing Co., 34, Southampton Row.) 9*s.* net.

Relations between the Effect of Stresses Slowly Applied and of Stresses Suddenly Applied in the Case of Iron and Steel Comparative Tests with Notched and Plain Bars. By Pierre Breuil. (London: E. & F. N. Spon, 125, Strand.)

Nominal Horse Power.

By A. T. J. KERSEY, A.R.C.Sc., Wh.Ex., A.M.I.Mech.E.

WHAT is meant by the term Nominal Horse Power, and has it any relation to the Indicated Horse Power of an engine? This is the question that suggests itself to every engineer, especially when he consults a catalogue with a view of purchasing an engine. The term has by no means fallen into disuse, as a study of recent catalogues of some makers of small engines will show, and its use is likely to mislead the uninitiated, as the actual horse power of an engine is usually many times its stated nominal horse-power. The formula which is generally used in estimating the N.H.P. of an engine is

$$\text{N.H.P.} = \frac{D^2 \times \sqrt[3]{L}}{k}$$

where D = diameter of cylinder in inches;
L = stroke in feet;
k = a constant which varies with different makers.

Now the I.H.P. depends upon p_m, the mean effective pressure in the cylinder, and the number of revolutions per minute, in addition to the quantities given above, yet it is usually stated that the I.H.P. of an engine will be a certain number of times its N.H.P. The following investigation was made by the writer to find out whether this was a correct statement and, if so, what the multiplier should be.

Let it be assumed that, for any engine

$$\text{I.H.P.} = \text{N.H.P.} \times n,$$

then

$$\frac{p_m \times 2L \times \cdot 7854 D^2 \times N}{33000} = n \times \frac{D^2 \times \sqrt[3]{L}}{k}$$

$$\therefore p_m = \frac{n \times D^2 \times \sqrt[3]{L} \times 33000}{k \times 1{\cdot}5708 \times L \times D^2 \times N}$$

$$= \frac{n}{k} \times \frac{21000}{\sqrt[3]{L^2} \times N}$$

Now, the boiler pressure and point of cut-off will be the same for all engines of the same class, and hence p_m will be constant. Since n and k are constants, hence, if the above is true, then

$\sqrt[3]{L^2} \times N$ = a constant for all engines of the same class. In order to find out whether this was the case, the writer referred to the catalogue of a well-known firm and from the data given deduced the values of k and $\sqrt[3]{L^2} \times N$ given in the following tables :—

SIMPLE NON-CONDENSING ENGINES.

N.H.P.	Diameter of cylinder.	Stroke.	Revs.	k	$\sqrt[3]{L^2} \times N$
4	6½″	9″	180	9·7	148
8	9″	12″	150	10	150
10	10″	14″	120	10·6	135

SIMPLE CONDENSING ENGINES.

N.H.P.	Diameter of cylinder.	Stroke.	Revs.	k	$\sqrt[3]{L^2} \times N$
12	12″	24″	100	15	159
20	16″	32″	75	18	146
30	20″	42″	57	20	131
40	2 . ″	48″	50	19	126
50	24″	48″	50	18	126

COMPOUND NON-CONDENSING ENGINES.

N.H.P.	Diameter of cylinde .	Stroke	Revs.	k	$\sqrt[3]{L^2} \times N$
6	4½″ & 8″	10″	200	13·2	178
12	6,″ & 11½″	14″	155	13·4	174
20	8″ & 14″	16″	135	14·3	164
30	10¼″ & 17½″	18″	120	15·2	157
40	12″ & 21″	24″	90	18·4	143

COMPOUND CONDENSING ENGINES.

N.H.P.	Diameter of Cylinder.	Stroke.	Revs.	k	$\sqrt[3]{L^2} \times N$
10	6½″ & 10″	12″	180	14·2	180
20	9″ & 14″	16″	135	15·2	163
30	11″ & 17½″	18″	120	16·3	158
40	13″ & 20½″	24″	90	18·5	143
50	14″ & 22½″	24″	90	17·6	143

It will be seen from these tables that the average value taken for k is as follows:—

10 for Simple Non-Condensing Engines;
18 for Simple Condensing Engines;
16 for Compound Engines, both Condensing and Non-Condensing.

Thus, in the case of Compound Engines, *the N.H.P. is the same whether condensing or non-condensing*; while in the case of Simple Engines, *the N.H.P. is less when condensing than when non-condensing*. On examining further into the matter, it is found that the non-condensing engines are designed to work with a boiler pressure of 100 lb., while the condensing engines work with a boiler pressure of 150 lb. This sufficiently shows the absurdity of using a formula which takes no account of the boiler pressure. A glance at the column showing the values of $\sqrt[3]{L^2} \times N$ shows that this is fairly constant for the same class of engine, being about 140 for simple engines and 160 for compound engines (in the case of a compound engine, for D^2 we substitute the sum of the squares of the diameters of the cylinders), so that the preceding assumption is justified and the formula has a rational basis in this respect. The trouble is that the so-called constant k varies from 15 to 40 or more according to the maker of the engine, and thus the 20 N.H.P. of one maker may be the 8 N.H.P. of another maker, so that comparison is impossible. If the use of the term is to be retained, surely some agreement should be arrived at with regard to the value chosen for k, as in this case the term might be useful in conveying some idea of the size of the engine without regard to its speed or steam pressure.

Taking the previous formula

$$pm = \frac{n}{k} \times \frac{21000}{\sqrt[3]{L^2} \times N}$$

we get

$$n = pm \times \frac{k \sqrt[3]{L^2} \times N}{21000}$$

Thus, in the previous case, taking $k = 18$ and $\sqrt[3]{L^2} \times N = 150$, we get

$$n = pm \times \frac{18 \times 150}{21000}$$

$$= \frac{pm}{8} \text{ approx.}$$

Thus, if the mean effective pressure for this particular class of engine is 56 lb. per sq. in., then $n = 7$, and

$$\text{I.H.P.} = \text{N.H.P.} \times 7.$$

Usually n varies from 4 to 8, so that the actual H.P. of an engine is always greatly understated when its Nominal Horse Power is given.

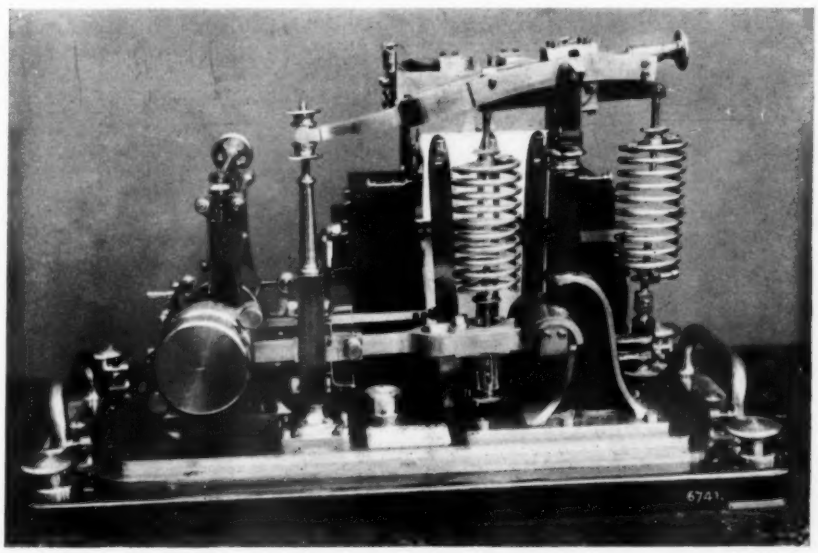
ENGINEERING PROGRESS

The Pallograph.

A HIGHLY improved form of apparatus called the Pallograph has just been constructed by Mr. Otto Schlick, of Hamburg, Germany, in conjunction with Mr. Maihak. This apparatus traces the amplitudes both of the horizontal and vertical vibrations of the keel of a steamship by means of two steel pens upon a strip of paper, which slowly unwinds, being driven by a clockwork. A third pen, impelled by a second clockwork, produces each second a trace on the strip of paper. There are in addition one to three further pens (according as the steamer has one, two or three engines and propellers), which are electrically driven from the engine. It may be mentioned that every engine part is fitted with a contact disc, which, with a given position of the crank, closes the circuit controlling the electro-magnet of the apparatus actuating the recording pens concerned. At the moment the crank occupies a given position (being, for instance, at the dead point), a mark will be traced on the strip of paper.

An additional steel pen may be arranged if desired, being moved by an electro-magnet, which is actuated by a push button on the bridge. This arrangement is specially suitable for trial trips on the measured mile.

The curves of the diagram supplied by the apparatus give an accurate indication of all the important data, such as would be impossible to obtain in any other way. From the shape of the curves the amplitude of vibrations and their periodical fluctuation are inferred both for the vertical and horizontal vibrations. The trace marked on the strip with each revolution



THE PALLOGRAPH.

of the engine in connection with the time marks, next allows of the number of revolutions of the engine per minute being ascertained correctly to 0·05. The diagram likewise enables us to ascertain how many vibrations have happened during one revolution of the engine, and at which point of the amplitude the part of the ship concerned happens to be when a given engine crank passes through the dead point. The employment of the apparatus in running off the measured mile is of particular value, the apparatus indicating: 1st, the exact time required for running off the mile, up to 0·05 sec.; 2nd, the aggregate number of revolutions of the engine, during the time required for running off the mile, up to 0·02 revolutions (provided the number of revolutions does not exceed 150 per minute); 3rd, the amplitude, frequency and characteristics of the vertical and horizontal vibrations.

Mr. Schlick's investigations have brought out the fact that the number of revolutions of the engine is subject to frequent fluctuations within 1 minute. It is consequently of particular importance to ascertain accurately the number of revolutions in order to gauge the performance of the engine. An analysis of the curves enables the causes of the vibrations to be ascertained, and eventually eliminated. The apparatus is therefore of the highest value, not only to steamers driven by reciprocating engines, but even more so to turbine steamers, enabling, as it does, the engineer to ascertain a faulty position of the propeller blades, which is one of the principal causes of vibration.

Sewage Disposal in Country Districts.

MANY country districts are still, owing to insufficient water supplies, without drainage systems, and the sewage is collected in cesspools. These cesspools are emptied, in most cases, by men with buckets and horse vans, the work having to be carried out at night and causing a nuisance in the neighbourhood. A better system is now adopted at Bournemouth, Rochester, Harrow, Harpenden, and in several other districts, where the Merryweather vacuum tank vans are in use. These vans each have air-tight containers, with hand-worked pumps. The latter exhausts the air from the tank, and on a suction pipe being placed in the cesspool and a valve opened, the sewage is lifted without causing a nuisance. A still further improvement, invented by the Greenwich firm, has just

VACUUM CESSPOOL EXHAUSTER

been put into service by the Romford Rural District Council. This is a self-propelled steam cesspool four-wheel trolley, which carries at one end a galvanised steel tank capable of containing 700 gallons of sewage. In front of the tank is arranged a double-cylinder vertical engine, which serves both for the purpose of propelling the vehicle and also of exhausting the air from the tank. The exhausting-pumps are arranged over the steam cylinders, and are connected to them direct. The crank-shaft of the engine is geared by means of steel toothed wheels to a differential shaft, having sprockets at the end which drive through steel roller chains to the rear wheels. There is also a rope hauling gear, which can be connected to the crank-shaft of the engine for pulling the machine over soft ground or other awkward places. The boiler is similar to those fitted on Messrs. Merryweather's steam fire-engines, but in the present case the tubes and water spaces are larger. The water-tank and coal-bunkers are arranged in front of the boiler. A direct-acting steam-pump and an injector are used for feeding the boiler. The total weight of the vehicle when fully loaded is 7½ tons, and with this weight it is capable of travelling at a speed of about 8 miles per hour on an ordinary road.

The action of the apparatus in emptying cesspools is as follows:—The air is first exhausted from the tank and is pumped into the ash-pan of the boiler to thoroughly deodorise and purify it. The pipes shown in the racks are then connected to a full-way sluice-valve at the rear of the tank, and are led to the cesspool. The sluice-valve is then opened, and the contents of the cesspool drawn into the tank. A large full-way outlet with a gate valve is provided in the rear of the tank, by means of which the latter can be quickly evacuated. The capacity of this apparatus is more than double that of the horse draught machines, and it can do its work far more rapidly. At a trial at the works recently the machine lifted a full load of heavy mud in less than five minutes, and travelled at eight miles per hour up a 1 in 10 gradient with ease. On the return to the works, the machine was weighed and found to turn the scale at 7 tons 10 cwts.

A New Electrical Works.

The demand for electric motors for industrial purposes continues to rapidly increase. To mention only one or two instances, the additional demand in Bristol for power in 1904 was nearly double that of last year, and about three times that of 1902. Again at Salford, motors representing over 2,000 h.p. were connected last year as against 1,005 h.p. in 1903, and Glasgow has had power consumption of 2,900,000 units, which is equivalent to over 80 per cent. during the year.

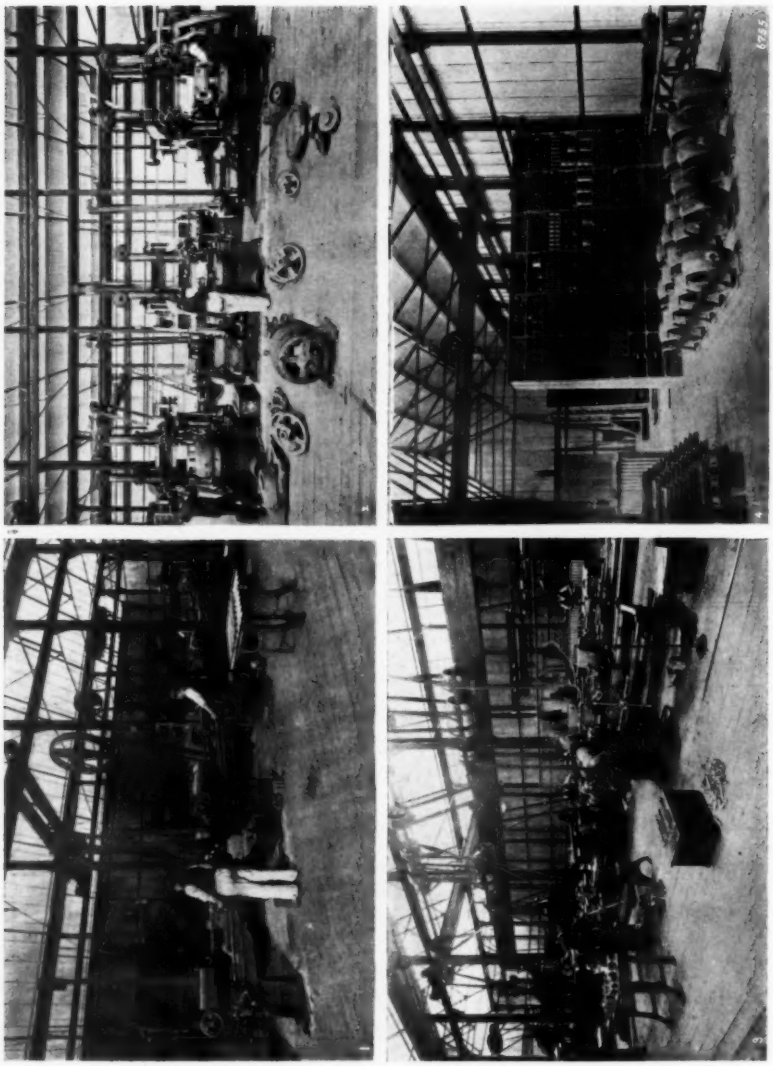
If the prices of standard direct-current motors be compared with those ruling, say, three years ago, it will be found that the cost has been lowered something like 50 per cent. This is due to the increased demand which has permitted manufacture in bulk and the standardization of parts, and has stimulated designers to obtain better results from a given weight of material and led manufacturers to instal specially designed and improved plant.

PLAN OF THE MORRIS-HAWKINS ELECTRICAL COMPANY'S WORKS.

The latest to enter the field of dynamo and motor manufacture is the Morris-Hawkins Electrical Co., who have taken advantage of the most up-to-date methods in the laying-down and equipment of their works and in the arrangement of the process of production.

The Morris-Hawkins Electrical Co., being a subsidiary Company of the Morris Aiming Tube and Ammunition Co., Ltd., have their new works built on land owned by the latter Company, at Dagenham, Essex. The site covers an area of 13 acres and is eleven miles from Fenchurch Street Station on the London, Tilbury & Southend Line. The Company also occupy commodious and conveniently situated Head Offices at 17, Charing Cross Road.

The scope of the undertaking at present is confined to the manufacture of direct-



1. GROUP OF LANG'S VARIABLE SPEED LATHES.
2. CAPSTAN AND TURRET LATHES.
3. GROUP OF BORING MILLS.
4. THE FINISHED STORES.

THE MORRIS-HAWKINS ELECTRICAL COMPANY'S WORKS.

current motors and dynamos in twelve standard sizes ranging from 1 to 100 b.h.p., although it is presently intended to take up polyphase and singlephase plant.

Stock sizes are put through the shops in such quantities as enables delivery of a machine within this range generally from stock. Further, the component parts are made in large quantities and are put into finished stores, so that should there be an abnormal call for a particular type or size of machine which would exhaust the completed stock, a machine could still be assembled and delivered at a few days' notice.

The accompanying illustrations show views of the plant and interior of the works. Fig. 3 shows a group of boring and turning mills supplied by Messrs. G. Richards & Co., Ltd., Broadheath, and Messrs Webster & Bennett, Coventry. These have been put down for machining the field magnets and bearing-end brackets. There is little doubt that Boring Mills for all kinds of chuck work are rapily superseding the ordinary face plate lathes. The advantages of the former are numerous and important, for, not only can work be set up more rapidly on the boring mill, but the operation is performed in a much shorter time and in a more satisfactory manner. It will be seen that these machines are of the very latest type, and the various speeds are obtained instantly from a gear box attached to the machine tool, rendering the overhead countershaft unnecessary. Smaller boring mills of a similar design but with turret heads are used for machining the armature end-brackets.

For dealing with the steel shafts on which the armature cores are mounted, Messrs. Lang's patent variable speed lathes have been adopted and give excellent results in working. The correct surface speed may be had for any diameter within the range of the lathes, however small the variation. A handwheel is conveniently placed so that the workman may get the correct cutting speed without handling the belt. The same operation which changes the speed moves an index to show at all times the diameter being turned. As will be seen from Fig. 1, a counter motion is not required. The shafts are ground all over, a very fine grinding machine by the Landis Tool Co., capable of accommodating shafts up to 4 in. in diameter, being installed for the purpose

A group of capstan and turret lathes illustrated in Fig. 2, are used principally for dealing with the commutator bushes and clamp rings.

Particular attention is given to the building of the commutator. The bars are made of the very best hard drawn copper, uniform in section, insulated from each other and from the shell with mica. The sections after assembling are submitted to a hydraulic pressure of 80 tons per square inch. They are then thoroughly baked, which gives them a true position, and further shrinkage does not take place. The process of manufacture enables the Company to turn out a thoroughly reliable commutator which will run perfectly true under severe working conditions even at high peripheral speeds.

The machinery in the Tool Room is chiefly American, although amongst others there is a universal milling machine by Messrs. Loewe. Throughout the shops Messrs. Newall's limit gauges are in use, the machine parts being made strictly to limit gauge and templet, and the jig system is adopted in the manufacture of all component parts ensuring perfect accuracy and interchangeability. All small tools, jigs, fixtures, etc., are made in the Tool Room and are returned there for renewal and repair. The work is checked after each operation, and all component parts are afterwards passed into the Finished Stores, for which ample accommodation has been provided (Fig. 4). As will be seen from the plan, the Company have ample room for extensions.

Due provision has been made for the comfort of the employees by suitable Dining rooms for both men and women.

The Power House is situated some little distance from the main shops and is equipped with one 120 h.p steam dynamo by Messrs. W. H. Allen; one 120 h.p. steam turbo-generator by Messrs. Greenwood & Batley, and an auxiliary steam set by the same firm.

In conclusion, we may say that the management of the business is in the hands of Mr T. Hawkins, as managing director, whose name was identified for many years with the well-known 'Byng-Hawkins' dynamos and motors.

A New Mechanical Woodworker.

We were recently afforded an opportunity of witnessing, at one of the Government factories, a new and ingenious mechanical woodworker, the invention of Mr. J. W. Wadkin, and now being manufactured by his firm, viz., Messrs. Wadkin & Co., at

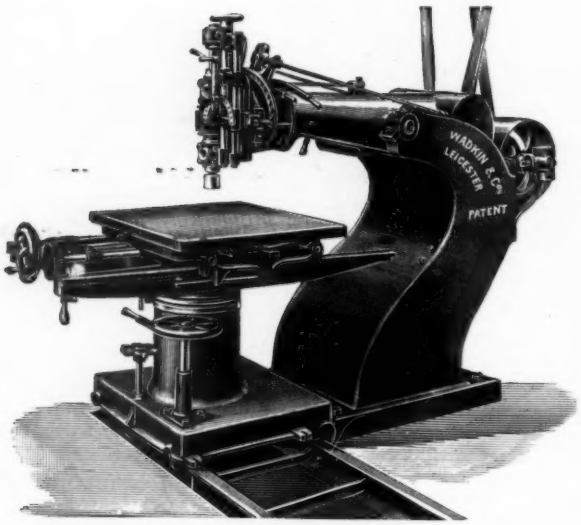


FIG. I.—MECHANICAL WOODWORKER: GENERAL VIEW OF THE MACHINE.

Evington Works, Leicester. The machine, which is the outcome of many years persistent work and costly experiments, possesses features of more than ordinary interest to wood-working manufacturers, and to engineering pattern-makers, as it takes a parallel place with the universal milling machine in ironwork over which, however, in many movements it goes further, viz., in the canting of the spindle-head, and the range of adjustment vertically and laterally. This universal movement of action and range of adjustment adapts it for a large variety of work, and renders it alike valuable in the small works where a very limited plant is available, and in large concerns where there is a highly specialized plant, the adjustment of which it is unadvisable to upset for ever-varying and awkward jobs.

The machine which is illustrated in perspective, front and side elevation at Figs. 1, 2, and 3, is self-contained, and occupies a comparatively small space. With the exception of sawing, planing and thicknessing, it can be economically employed on the following operations which, although not representing the full compass of the machine, will nevertheless serve to give an idea of its scope: regular and irregular moulding, tenoning, haunching, cross-cutting, housing, dovetailing, boring, slot-mortising, recessing and trenching, turning, fluting, shaping square, and moulded work of every description.

The machine consists of strong solid cored frame of cast iron supporting an overhanging extension arm carrying a spindle-head. The arm rocks vertically on sensitive bearings, and can be depressed to a low angle. It has an exceptionally long over-reach, well clear of the main frame. On the latter are two trunnions, A, supporting the overhanging arm, which is of cast iron and half-circular in section. The range of its rise and fall is 16 in. At the front of the arm is large spindle-head, the form and combinations of which form an essential feature of the machine. This head, which consists of a solid casting, is pivoted to swivel to any desired angle, from the vertical to the horizontal, and end for end, the motion being provided with a graduated scale, B, for instantly setting to any desired angle of cut. On the spindle-head are arranged the plummer blocks carrying the spindle. The latter has a reversing motion and is free to slide within its bearings independently of any movement of the head, and is fitted with a quick-acting positive adjustment and a micrometer screw adjustment for fine work, this being regulated by the sector S, and effected by the handle C. The spindle, which is of the best forged steel, is rotated by a pulley keyed on to it and driven by a belt from the countershaft. To allow for the driving at any angle of inclination of the arm, compensating pulleys have been fitted within the latter. Particular care has been bestowed upon the spindle bearings D, those portions which are subjected to the greater pressure owing to the pull of the belt being in phosphor bronze, while the lubricating sides are of white metal.

The table mounting is a heavy cored casting free to move bodily upon its foundation frame on runners, which are actuated through a pinion, spindle and hand wheel, S. The rollers run on a rail frame fastened to a floor or a concrete

bottom. The table can be instantly moved across the front of the machine from under the cutter spindle and sideways, clear altogether of the machine head, in which latter position the spindle-head can be lowered under the level of the table top. The table carrier can be secured in any position by the clamp T.

The table is carried on a column accurately fitting the outer body, both column and table being raised and lowered through a distance of 12 in. by means of a screw, N, which passes through a sleeve cast into the column. In addition to the lateral movement of the table body, the table is provided with a longitudinal and cross motion, and is moved upon sensitive runners actuated quickly either by hand or by a positive screw and rack motion. Further, it can be turned through a complete circle horizontally.

These combined movements enable the work to be firmly fixed flat upon the table, any angular cuts and adjustments being made by turning the table horizontally and swivelling the machine head vertically. The work need only be rough set, the fine adjustments being readily effected by the screws. Automatic stops are fitted throughout to facilitate and render accurate repetition work.

The machine is driven in the usual way by belting from a main shaft the pulleys running on a countershaft supported by two brackets which are bolted on to the back of the frame casting. The striking gear is arranged behind the spindle-head, and can be actuated from either side. When arranged for electric driving the motor is fixed on the countershaft

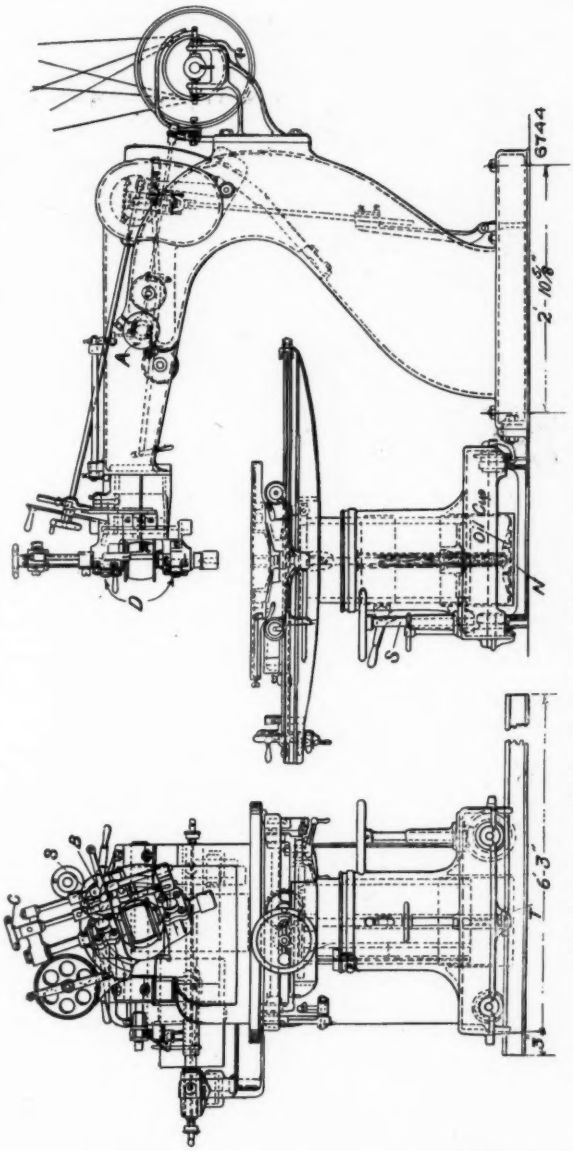


FIG. 2. DETAILS OF MECHANICAL WOODWORKER. FIG. 3.

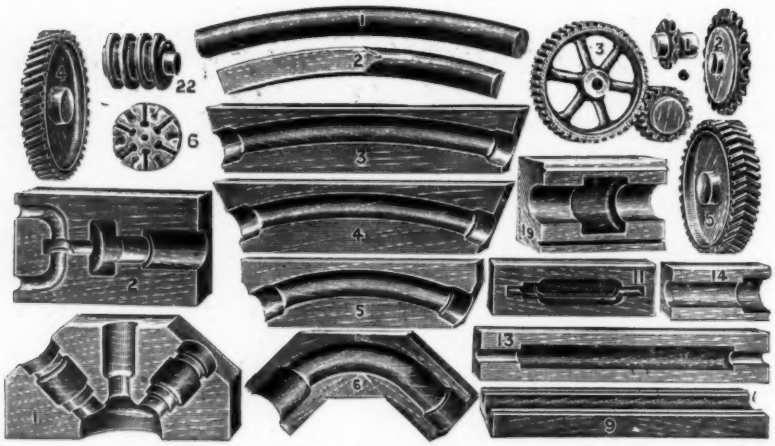


FIG. 4.—SPECIMENS OF PATTERN WORK EXECUTED BY THE WOODWORKER.

brackets, and drives direct on to the pulley shaft.

As much attention has perhaps been bestowed upon perfecting the cutters as on the machine itself. They are of solid turned type, which keep their form longer than most cutters, owing to their being sharpened and ground on the inside edge. They are made of special steel and are formed to gauge, to ensure accuracy of fit to the scribed or other parts. They are made in great variety to suit the varied range of work which the machine is capable of executing.

With suitable dividing heads attached to the table top, any gear pattern with helical, spiral, straight or other teeth can be cut, similarly as iron gear wheels are cut in the milling machine. The cutters, however, are not the costly item as are milling cutters. A very plain, simple, flat, inexpensive cutter only is required, which it will pay to make to cut any one single gear pattern.

In addition to the time saved over hand labour, the teeth in this case can be cut out of a solid block of suitable wood roughly sawn to diameter, as accurately as those of any iron wheel cut in a miller, which is a very different matter when gear patterns are cut by hand, however skilled the workman.

The teeth of specimen wheel No. 3, shown in Fig. 4 (number of teeth 38, 9 in. diameter by 2 in. wide) were cut in twenty minutes. The half section arms and boss are cut out of the solid complete as shown, no turning in the lathe being necessary. The specimen cutter head (No. 6) was also cut out of the solid.

Straight round cored boxes up to 12 in. diameter, or larger if necessary, or pipe bends any radius can readily be worked with saws and other simple inexpensive cutters. Boxes trenched out square section to any desired width, with reduced ends, can be cut out of the solid. Core boxes up to 28 ft. radius, forming the socket and spigot ends complete, have been cut by the machine.

In small, plain, straight core boxes a bead and groove each side the core groove is formed all at one time, obviating the necessity of pegs for fixing the two halves in strict relation to each other.

Routing out of solid bodies and forming

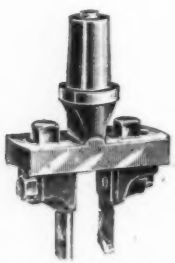


FIG. 5.—EXPANDING HOUSING CUTTER, WITH REMOVABLE CUTTERS. EXPANDS FROM $\frac{3}{8}$ IN. TO $1\frac{1}{4}$ IN.

FIG. 6.—ROUTER CUTTER, WITH REMOVABLE CUTTERS.

webs out of the solid can be rapidly and accurately worked with very simple cutters, as can heavy work on cylinders.

Appended are the comparative times occupied by the machine and ordinary methods respectively in producing the pattern work shown in Fig. 4:—

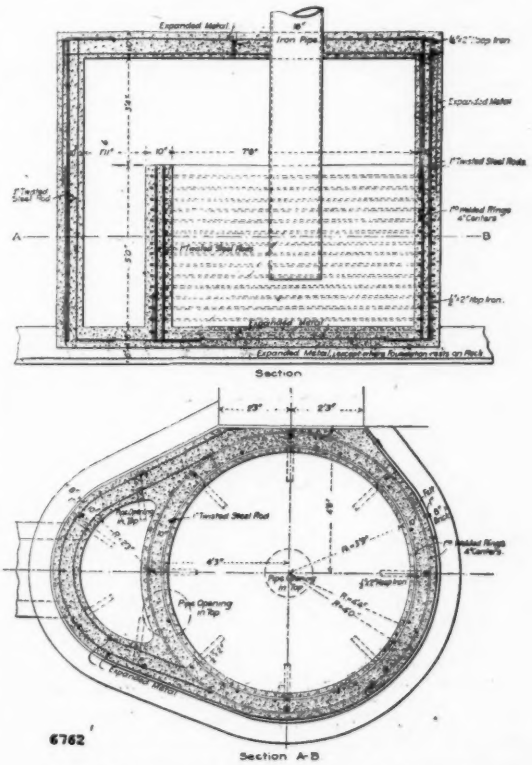
No.		Usual Method. about	Mechanica Wood-worker. about
1	Valve Core Box	30 hr.	2 hr.
2	,, ,, ...	20 ,,	1½ ,,
1	Sprocket Wheel, 4 in.	4½ ,,	15 min.
2	,, ,, 12 in.	15 ,,	20 ,,
3	Spur Wheel, 10 in.	20 ,,	2 hr.
5	Helical Gear ⅞ in. p., 38 teeth	27 ,,	40 min.
22	Worm, 7 in long, 5 in. ...	15 ,,	15 ,,
6	Cutterhead	14 ,,	1¼ hr.
1	Pipe Pattern, 28 ft. radius, 4 in.	8 ,,	½ ,,
2	,, ,, 18 ft ,,	8 ,,	½ ,,
3	Pipe Core Box, 28 ft. ,,	10 ,,	½ ,,
4	,, ,, 18 ft. ,,	10 ,,	½ ,,
5	,, ,, 8 ft. ,,	10 ,,	½ ,,
6	Pipe Quarter Bend, 4 in. ...	10 ,,	½ ,,

It would thus appear that this interesting machine is able to accomplish intricate work of all kinds economically as compared with hand labour, and possesses important advantages by reason of its flexibility over ordinary machines, which, when not employed upon their special work, will not take ordinary work.

Hot-Wells of Concrete Steel.

An interesting adaptation of concrete steel construction is to be found in the power station for the recently-opened Interborough Rapid Transit Co. of New York, where hot-wells of reinforced concrete have been provided for the condensers. The latter are of the barometric type, which is better known in America than in this country, and is well adapted for maintaining the high vacuum required for turbines. For this reason it is being employed at the new Neasden power-house of the Metropolitan Railway. Its action depends on the exhaust steam and circulating water being brought into intimate contact in a large chamber, in which the velocity of the former is greatly reduced, and the latter is high divided by spraying. The special advantage of this condenser, irrespective of the economy, is that the air or vacuum pump is greatly assisted in its work by a removal of a large portion of air in the exhaust steam by inductive action of the water spray in falling through the condenser and tail pipe. In fact, should the dry vacuum pump get temporarily out of order, the condenser will still maintain a vacuum—at a reduced degree, but nevertheless sufficient to enable the engine to be run condensing.

The condensers at Rapid Transit power station are located against the low-pressure cylinders of the engines, and have their tail pipes dropping vertically downward into the engine-house basement. The power station foundation includes a monolithic floor of concrete, through which, at intervals, are transverse conduits to carry the discharge from the condensers to the main



DETAILS OF CONCRETE STEEL HOT WELL USED IN NEW YORK SUBWAY POWER HOUSE

conduit, which is run underground, to the North River. It is, of course, essential that the bottom of the tail pipe be submerged with a sufficient volume of water, so that when the dry vacuum pump is put in operation, in starting up the corresponding engine, a column of water may be lifted in the tail pipe without destruction of the vacuum. By the use of a tank resting on the floor of the engine-house basement, the desired submergence is obtained conveniently, with easy connection to the transverse discharge conduits. These tanks have been built of reinforced concrete.

As shown in the accompanying illustrations, for which, together with most of the details, we are indebted to the *Engineering Record*, the well proper is 7½ ft. in inside diameter, while the overflow connection into the discharge gives it an egg-shape horizontal cross section. It has 10-in. walls, an 8-in. bottom, while its top, which fits tightly about the tail pipe, is also 10 in. thick. The tail pipe stops within about 1½ ft. of the bottom, and by means of the dam or baffle shown, 5 ft. of water can be trapped within the well. From the top of the well provision is made for a second pipe which serves as a discharge for any vapour which may arise, and there is a drip pipe which pierces the roof of the well over the outflow portion, for the discharge to waste of oil-laden water from the engine.

The system of reinforcing is indicated clearly in the drawings. The walls of the well proper are reinforced with 1-in. welded rings placed in pairs on 4-in. vertical centres, one ring near the inner surface of the well and the other toward the outer surface. Placed vertically between these, distributed in the manner indicated, are 1-in. twisted steel rods peculiar to the Ransome system of concrete reinforcement. These vertical rods are also employed in the walls of the outflow portion of the hot well, but the rest of the reinforcement consists of expanded metal, which is also used in the bottom and in the cover of the well. In addition, where the walls join the top and bottom, it will be noted that there is reinforcement consisting of ¼ × 2-in. hoop iron bent and spaced as shown.

The Measurement of the Flow of Water.

THE measurement of the rate of flow of a river or canal has been and is still a subject of investigation. The sail-wheel of Woltmann, Pitot tubes, water gauges and floats have all been put under contribution with more or less success.

If the Pitot tube and the Woltmann wheel form an apparatus convenient for use, their exactitude leaves something to be desired when the rate of flow is small; and the employment of floats does not enable a determination of the flow at different depths to be made: thus only an approximation of the mean value of the flow is obtainable in this manner.

A writer in the *Centralblatt der Bauverwaltung* proposes a new method of utilizing floats by which a determination may be made of the flow at different depths.

In Fig. 1 consider a ball of small density maintained at a point B. If the ball be freed it will rise vertically if the water is not moving, that is if $v = 0$. The rate of ascent will be in proportion to the relative density of the liquid and the ball. If the water be moving, the ball will not rise vertically, but will describe a trajectory whose horizontal projection $A\,C = l$ will be in proportion to the mean rate of flow.

The quotient $\frac{l}{t}$ may be approximately considered as the mean rate of flow of the various layers of liquid in the neighbourhood of the section $A\,B$ and area $B\,A\,C$. The values of l and t may, according to the writer, be easily determined by employing, for example, a copper ball 5 cm. diameter, more or less ballasted according to the current. For rates of flow of 1-2 cm. per second, a density equal to ·9 is suitable; for rates approximating to 1 metre, a density of ·03 is to be preferred, a celluloid ball being employed.

Figs. 2 and 3 show a small apparatus by which the ball may be held in position and let go at any given moment. To effect the latter it is only necessary to pull the cord which frees the pin n and enables a spring to open out the two portions of the apparatus.

The measurement of l is made by means of graduated floating rule placed in such a way that the zero mark is in a line projected vertically from the centre of the ball as in Fig. 4. Where the flow is relatively large in place of the rule a floating panel, of which Fig. 5 is a plan, may be employed, and which is furnished with a paddle to keep it in the direction of the stream. The ball, on rising, will lodge itself between two of the horizontal blades of the float, the vertical distance $A\,B$ being selected and known. It suffices to note the time

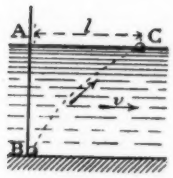


FIG. 1.

FIG. 2.

FIG. 3.

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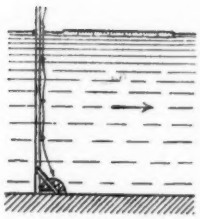

FIG. 4.

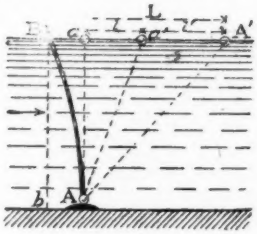

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FIG. 6.

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FIG 5.

occupied by the ball in travelling from *B-C*, Fig. 1, and to measure the distance $l = A\,C$.

When the current is very strong the cord, *A B*, by which the ball is freed, may be deviated from the vertical as at *A B*, Fig. 6, in which case an error will be obtained in the result. To avoid this a differential method is employed, two balls of different density being simultaneously freed by the same apparatus. One of these will emerge at a' in a certain time, t, and at a distance a, $a' = l$ from the vertical $a\,A$, the position of which is not known. The other ball will emerge at A' in time T, at a distance $a\,A' = L$. From this we have

$$v = \frac{l}{t} = \frac{L}{T} = \frac{L-l}{T-t}$$

that is

$$v = \frac{l'}{T-t}$$

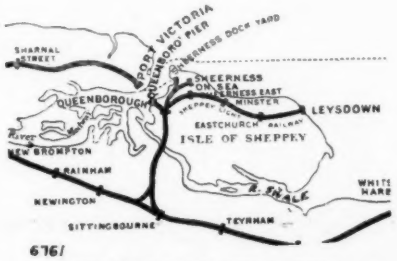
It is only necessary therefore to measure the length $l' = a'\,A'$ and the times T and t to obtain the mean rate of flow almost as easily as in the general case.

The New Swale Bridge.

An interesting example of bridge construction is afforded by the operation, recently carried out under the personal supervision of Sir William Arrol, of substituting, for the old centre span of the railway bridge over the River Swale at King's Ferry, a steel bascule of the Scherzer rolling type. This, as is well known, offers facilities for erection with minimum interference of traffic, and in this case it provides the further advantage of bridging by one draw-span the whole width of the centre channel, instead of two that were formerly employed. In accordance with a notice issued by the South-Eastern and Chatham Railway Company, the bridge was closed for traffic on a given Sunday to permit the contractors to effect the substitution of the bascule for the old centre span, which, owing to an unexpected structural weakness having developed, had to be riveted down.

The bascule, weighing some 350 tons, had previously been erected over the old bridge at a sufficient height to permit the passage of trains beneath, an operation which, as may be imagined, was attended with no small difficulties and employed a staff of Sir William Arrol & Co. for upwards of two years.

The method of removing the old span was as follows:—Two large lighters, each capable of carrying a weight of 200 tons, were placed in position under the centre arch, and over which was constructed a cradle of heavy baulks of timber, built at such a



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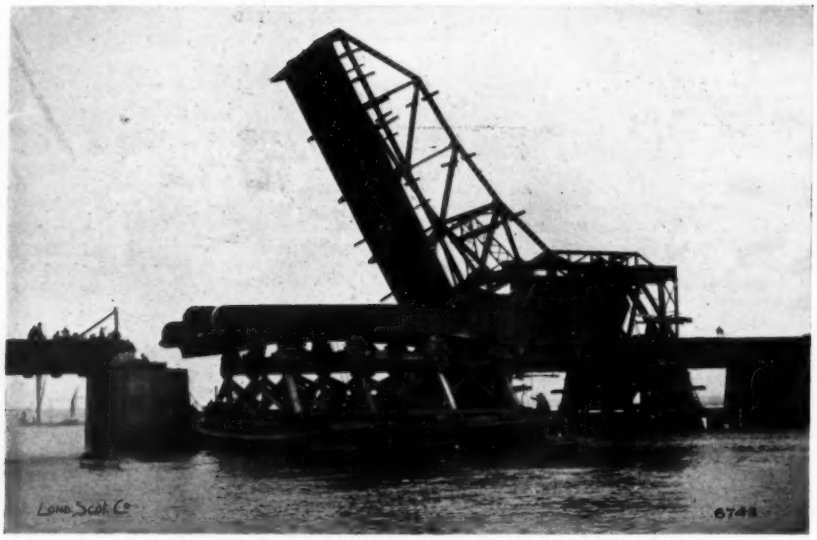
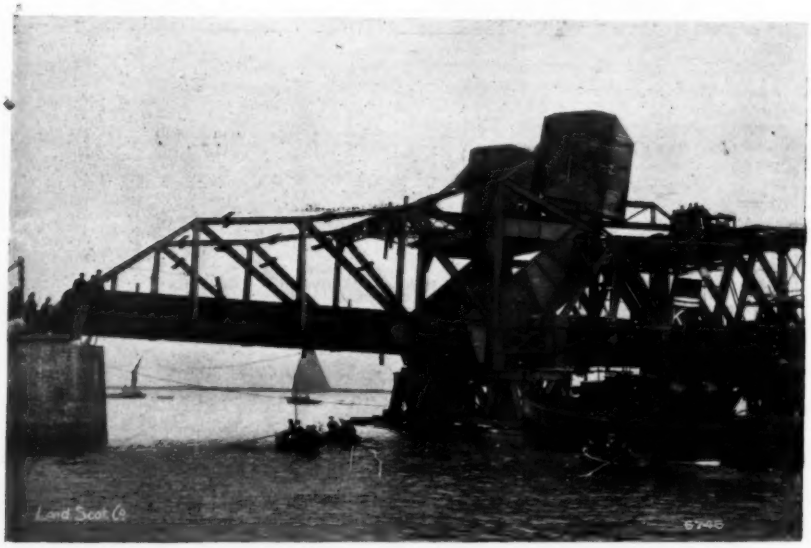
MAP OF SWALE RIVER AND DISTRICT.



N&W SWALE BRIDGE: REMOVING THE OLD SPAN.



NEW SWALE BRIDGE: THE BASCULE LOWERED IN POSITION.

height that, just before high water, the staging reached the level of the span that was to be removed. This portion of the bridge had been unriveted and detached beforehand, so that the timber cradle, rising with the tide, would reach and lift the span. This happened shortly before 9.30, and in half an hour the span had been floated out by the tide clear of the bridge. The weight of the span removed was 190 tons, and its length 65 ft. The old span having been removed, the work of lowering the bascule was commenced and successfully carried out.

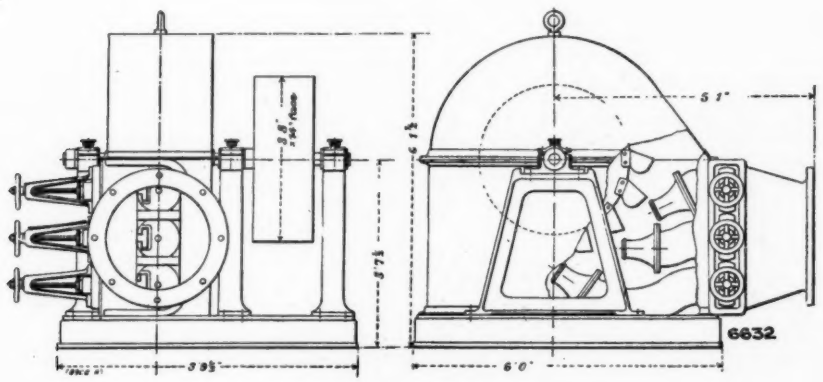
The new span, which is estimated to cost £50,000, has been erected to accommodate those of the vessels with fixed masts engaged in the large and important water traffic between Sittingbourne and London. As there is also a considerable railway traffic over the bridge—the line forming a portion of the direct Queenborough and Flushing route, and also of the line to Sheerness and the Isle of Sheppey—it is of importance that the operation of raising and lowering the bridge be carried out with as little delay as possible. The lifting equipment is therefore electrically driven, current being generated by dynamos driven by two 20 h.p gasoline engines installed in a power station erected close to the bridge.

The work has been carried out to the plans of Sir Benjamin Baker, who has acted in conjunction with Mr. P., C. Tempest, the chief engineer to the railway company.

50 B.H.P. PELTON WHEEL.

50 B.H.P. Multiple Nozzle Turbine Wheel.

THE Pelton wheel illustrated herewith has been constructed by Mr. Percy Pitman, of Ledbury, Herefordshire for the purpose of driving air-compressors and drop stamps in connection with the prospecting plant at some gold mines in South America. The wheel, which is of the multiple-nozzle type, has been designed to give 50 brake horse-power at a speed of 135 revolutions, when using 700 cubic feet of water per minute at 50 ft. head. The water enters by a branch 24 in. in diameter, and passes to the three nozzles through three valves controlled by the hand-wheels

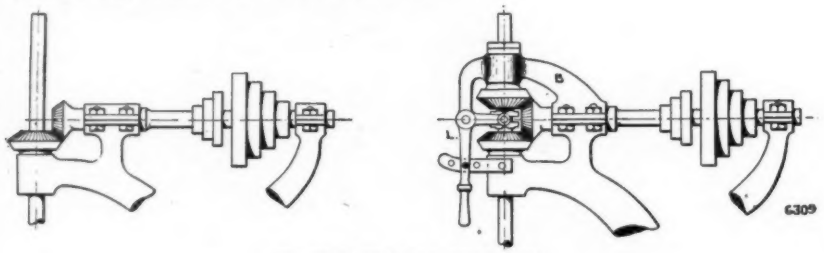


DETAILS OF 50 B.H.P. PELTON WHEEL.

outside. The valve-screws are double-threaded, and are entirely outside the casing, the spindles being packed by stuffing-boxes, and the bonnets made easily removable, so that valves, etc., can be withdrawn, if necessary, without breaking any pipe-joints. The nozzles are each $3\frac{5}{8}$ in. in diameter, and they, together with the whole of the buckets, bearings, valves, and seatings, are constructed of phosphor-bronze to prevent corrosion. The wheel itself is made of steel plate, $\frac{1}{8}$ in. thick and 4 ft. in diameter, mounted on a 3 in. shaft, and turned and balanced after being keyed up. It will be seen that the buckets are widened out at the sides more than is usual, this having been done to allow the water to spread, and leave the wheel freely when its velocity has been abstracted.

The casing is constructed of $\frac{1}{4}$ in. steel plates, riveted on a framing of angles by $\frac{1}{2}$ in. rivets at 3 in. pitch. It is caulked at all joints, and is water-tight. The top half of the casing may be lifted off, and half of one of the lower sides is also made removable, so that all buckets and nozzles may be conveniently got at or removed.

Reversing Gear to Vertical Drill.



REVERSING GEAR TO VERTICAL DRILL

We had four vertical drilling machines of American pattern, as shown on the left of illustration, which were in constant use for drilling tapping holes in light brass work.

The tapping was done on another machine, as the upright drills had no reversing motion to spindle for backing the tap out. We, therefore, designed the attachment shown on the right, which gave us the desired result and made the field of operations far wider, as all kinds of light tapping up to $\frac{3}{4}$ in. can be easily accomplished; they have been working now about 18 months and are a great success. It consists of a cast-iron bracket *B* carrying the bevel wheel—bossed up to form a sleeve—and having a small vertical arm on the front for a fulcrum for the cranked reversing lever *L*. The bracket is bolted on the main bearing of the horizontal driving-spindle as shown, the top part or cap being removed for this: as the bracket is babbited and takes its place, the bevel wheel with hollow sleeve attached is made a nice running fit in the bracket and secured with nuts at the top. Both the bevel wheels on the drill spindle are recessed on the inside ends which are facing each other, and a mild steel ring, having a portion cut away to form claw-clutches, is inserted and held with a couple of screws, the rings being previously case-hardened. A double-claw-clutch, keyed on the vertical spindle, is moved by the forked reversing-lever, and engages with one or other of the bevels running loose on the spindle. The operator can instantly change the rotation by moving the handle of reversing lever. A hole is drilled through the handle as shown, and three holes in the steady arm, a turned pin keeping the clutch in or out of gear.

J. Green.

METALLURGICAL PROGRESS.

By PERCY LONGMUIR, National Physical Laboratory.

Steel.

High Speed Tool Steel.—High speed steels are a source of fascination to the metallurgist, and of high potentiality to the engineer. Following on the work of Messrs. Taylor and White, much commercial research has been devoted to these steels; however, for various reasons, the greater part of this research is as yet unpublished. It is, therefore, with special interest that we turn to a paper by Mr. J. M. Gledhill, read before the American Meeting of the Iron and Steel Institute, in which the author, whilst detailing the manufacture, specially emphasizes intelligent after treatment. A minor though important point to the user is found in the advice not to break the steel cold, but cut it to size while hot, thereby minimizing incipient end fissures, which are apt to develop on subsequent hardening. In producing these steels, the best results are obtained from a Swedish base and a crucible furnace product. Modern high speed steels represent combinations of iron and carbon with (1) tungsten and chromium; (2) molybdenum and chromium; or (3) tungsten, molybdenum, and chromium. Many experiments have been made on the comparative cutting power of steels produced, by varying the proportions of these elements, and the results are outlined in the following:—

Carbon.—A series of steels containing from 0.4 to 2.2 per cent. carbon were hardened by heating to the highest possible temperature without destroying the cutting edge and rapidly cooled in a srong air blast. By this method of hardening the greatest cutting efficiency was found in steels containing from 0.4 to 0.9 per cent. carbon.

Chromium.—A series containing from 1 to 6 per cent. were examined, and it was noted that the lower members of the series performed good work on mild steel, but were not so efficient on harder materials. Higher contents of chromium yield better results on hard materials, and a point here noted is that an increase in chromium involves a decrease in carbon, in order to obtain the highest efficiency.

Vanadium.—A steel containing 2 per cent., readily forged, and was hardened from a white heat by cooling in an air blast. The tool, tried on a medium steel, stood well, but not better than a steel containing the cheaper element chromium.

Tungsten.—Experiments were conducted on a series of steels containing from 9 to 27 per cent. tungsten. From 9 to 16 per cent., the cutting efficiency is increased, but is accompanied by an increase in brittleness, and the latter figure appears to be the limit of cutting efficiency. From 18 to 27 per cent., the steels became softer, and whilst tools from them cut cleanly, they do not stand so well.

Molybdenum.—The influence of this element is at present under investigation, but results already obtained show it to be far more active than tungsten. These steels also require a lower hardening temperature than tungsten steels, for if the temperature exceeds 1,000 deg. C. the working life of the tool is shortened.

Tungsten and Molybdenum.—The presence of from 0.5 to 3.0 per cent. molybdenum in a high tungsten steel slightly increases the cutting efficiency, but the advantage gained is altogether out of proportion to the cost of the added molybdenum.

Silicon.—A series of rapid steels were made with silicon, varying from a trace to 4.0 per cent. This element sensibly hardens such steels, and the cutting efficiency is increased by additions up to 3.0 per cent., but beyond this figure the cutting efficiency begins to decline.

In view of the foregoing, the following analysis of one of the best qualities of rapid steels produced by the author's firm is of interest:—Carbon, 0.55 per cent.; chromium, 3.50 per cent.; tungsten, 13.50 per cent.

Turning to the treatment of such a steel, the necessity of careful annealing is dwelt on, and the most suitable temperature is found at about 1,400 deg. F., this temperature being maintained from 12 to 18 hours, according to the section of the bars. Annealing not only minimizes the risk of cracking when the steel is hardened, but also renders it sufficiently soft to be machined into any desired form of tool. Hardening temperatures vary according to the class of tool. Thus, with turning or slotting tools the points only are gradually raised to a white melting heat, then placed in an air blast, and after grinding are ready for use.

When hardening in oil, the tools should be first raised to a white heat, short of melt-

ing, cooled in air blast or open air down to a bright red (1,700 deg. F.), and then plunged into a bath of whale or rape oil.

Tools that do not permit of grinding to shape after hardening, such as twist drills, milling cutters, and the like, are treated as follows:—A specially arranged muffle, formed of two chambers so arranged that in the lower one a temperature of 2,200 deg. F. may be steadily maintained, whilst the upper one is kept at a much lower temperature, is used for heating. The cutters are warmed through on the top of the muffle, and then placed in the upper chamber and uniformly heated to a temperature of about 1,500 deg. F. They are then transferred to the lower one, and remain until a temperature of 2,200 deg. F. is reached. The tool is then withdrawn, whilst its edges are sharp and uninjured, and revolved in front of an air blast until the red heat has passed away. Whilst the tool is still warm, it is immersed in a bath of tallow at about 200 deg. F.; the temperature of the bath is then raised to about 520 deg. F., on reaching which the tool is withdrawn and plunged into cold oil.

*The Influence of Carbon Phosphorus, Manganese, and Sulphur on the Tensile Strength of Open Hearth Steel.**—Mr. Campbell's paper records a large number of results obtained by testing various groups of acid and basic open hearth steel, classified, first, according to their carbon content, and then subdivided according to their contents of phosphorus, manganese, and sulphur respectively. The extent of the work may be gathered from the fact that the acid series comprised nearly 700 bars, whilst the basic one represents some 1,100 heats. All the bars tested are comparative; in other words, the operations of forging, rolling, testing, analysis, etc., were conducted under similar conditions. Duplicate determinations were made on each bar for phosphorus and manganese. Carbon was determined in three ways—(1) by combustion, on drillings from the bar; (2) colour test, on drillings from the bar; and (3) colour test on the ingot from which the bar was forged. Three tensile tests were broken from each heat, two on one machine and one on another. Figures quoted in the paper represent the average results obtained on the two machines, *not* the average of the three bars. In order to plot the data, all heats were combined which contained from 0.075 to 0.125 per cent carbon, from 0.125 to 0.175, and so on, making a division for each additional 0.05 per cent. carbon.

The conclusions drawn are summarized as follows:—

Carbon.—In acid steel, each 0.01 per cent. of carbon strengthens the steel by 1,000 lb. per square inch., when the carbon is determined by combustion. The strengthening effect is 1,140 lb. for each 0.01 per cent., as determined by colour, owing to the fact that the colour test does not determine all the carbon present. In basic steel, each 0.01 per cent. of carbon strengthens the steel by 770 lb. per square inch, when the carbon is determined by combustion. The strengthening effect is 820 lb. for each 0.01 per cent. as determined by colour.

Phosphorus.—Each 0.01 per cent. of phosphorus strengthens the steel by 1,000 lb. per square inch.

Manganese.—Below a certain content, the influence of manganese is complicated by some disturbing condition, probably oxide of iron, so that a decrease of manganese in very low carbon steels is accompanied by an increase in strength. In acid steels, each 0.01 per cent. increase of manganese above 0.4 per cent. raises the strength by 80 lb. per square inch in a steel containing 0.1 per cent. carbon to 400 lb. per square inch in a steel containing 0.4 per cent. In basic steel, each increase above 0.3 per cent. raises the strength by amounts varying from 130 lb. with steel containing 0.1 per cent. carbon to 250 lb. with steel containing 0.4 per cent. carbon.

Sulphur.—The effect of this element on the strength of acid and of basic steel is very small. From these results the following formulæ may be written, in which C = 0.01 per cent. of carbon, P = 0.01 per cent. of phosphorus, Mn = 0.01 per cent. of manganese, R = a variable to allow for heat treatment.

The coefficient "x" of manganese in acid steels is derived from values shown in one of the tables, and applies only to contents above 0.4 per cent. The coefficient "y" is derived from another table, and applies to basic steels in which the content of manganese exceeeds 0.3 per cent.

Formula for acid steel, carbon by combustion:—

$$40{,}000 + 1{,}000\ C + 1{,}000\ P + x\ Mn + R = \text{Ultimate strength.}$$

Formula for acid steel, carbon by colour:—

$$39{,}800 + 1{,}140\ C + 1{,}000\ P + x\ Mn + R = \text{Ultimate strength.}$$

Formula for basic steel, carbon by combustion:—

$$41{,}500 + 770\ C + 1{,}000\ P + y\ Mn + R = \text{Ultimate strength.}$$

Formula for basic steel, carbon by colour:—

$$42{,}000 + 820\ C + 1{,}000\ P + y\ Mn + R = \text{Ultimate strength.}$$

The Harmet Method of Producing Solid Ingots—Mr. R. Fischer, in a recent issue of *Giesserei Zeitung*, describes at length the Har-

*American Meeting of the Iron and Steel Institute.

met process for obtaining solid and sound ingots. Practically, the method is compression, the pressure being applied from the bottom of the ingot mould—an effect which may be increased by the conical form of the moulds imparting a side pressure. Thus, the arrows of Fig. 1 indicate the direction of the pressure. Fig. 2 shows one type of press employed, where it will be noted the truck "*h*" is recessed to take the mould "*d*," thereby strengthening the bottom flange. Sufficient pressure is exerted on the head "*g*" to prevent upward straining, pressure acting on the lower head "*f*" forces the plastic ingot upwards, the slightly conical section of the mould intensifying the compression. Other types are noted; one of them includes a pair of moulds supplied by a central runner connected to gates at the bottom of each mould. After casting, pressure is applied at the bottom, and the tops are left open.*

Some of the Significant Features of American Rolling Mill Practice.—In a most able and comprehensive article, Mr. D. F. Nisbet† discusses the salient features of American practice. Commencing with mill engines, the fluctuation in load is noted. For instance, a three-high plate mill will roll 300 plates per day of 22 hours, each plate requiring 15 passes, the time per plate being 4.4 min. In other words, the engine power will fluctuate from friction load to full load 15 times during the rolling of one plate, making a total of 4,500 fluctuations per day. Hence a limit is at once placed on the measure of economy obtainable in such engines. Mill engineers are criticized for their apparent neglect of condensation; now, to secure real economy, the condenser must operate under favourable conditions, few of which are met with in mill practice.

Electrical Appliances.—For operating carrier tables of the straight way type and for tables in which reversals are infrequent, electrical motors are most suitable. But for tables undergoing frequent reversals, such as for blooming mills, slabbing mills, etc., the small reversing engine is far better and, on the whole, more economical.

Ingot Stripping.—The stripper is now universally of the vertical type, operated by hydraulic power; electricity, or a combination of both, and supersedes the older form of ingot extractor.

Pit Furnaces.—Gjer's soaking pits have not found favour in American mills, and recourse has been had to vertical gas-fired heating furnaces, having from one to five pits. Those with one large pit are provided with three or more covers, each operated by a hydraulic cylinder, so that only a portion of the pit is exposed at one time.

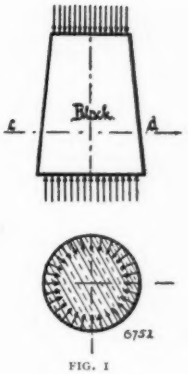


FIG. 1

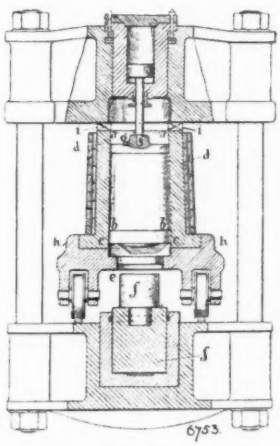


FIG. 2.

Blooming Mills.—The two-high reversing mill has been generally adopted, owing to the fact that it permits the rolling of smaller sections to lengths impossible where the lifting tables necessary with three-high mills are used. For mills where the ingot is rolled into a 6 in. × 6 in. or larger bloom, and therefore of comparatively short length, a three-high mill is preferred. In size, blooming mills range from 29 in. in diameter, with an output of from 600 to 900 tons per 24 hours, to mills of 42 in. diameter rolls, producing from 1,200 tons upwards.

Slabbing Mills.—The slabbing mill is simply a large and powerful universal mill, having usually but one pair of vertical and horizontal rolls. The vertical rolls may be

* See also Metallurgical Abstracts in January, 1904, issue of this REVIEW, p. 73.

† *The Iron Trade Review*, Vol. xxxvii., No. 43.

brought near enough to edge slabs 12 in. or 14 in. wide, and can be retracted until their outer surfaces clear the passes in the ends of the horizontal rolls. With the vertical rolls in their extreme position, the mill may be used as an ordinary blooming mill.

Bloom and Billet Shears.—The shear given preference for cutting the product of the blooming mill into lengths suitable for use in the finishing mill is the vertical hydraulic type, having a movable bottom and a fixed top knife, so that in cutting the bloom is lifted away from the table rollers.

Plate Mills.—The three-high mill with top and bottom rolls of a larger diameter than the middle one is practically the only type used. A two-high "hand over" roughing mill is occasionally, though rarely, used in conjunction with the three-high one. These mills sometimes work on ingots, but more usually on slabs.

They are invariably served with tilting, run out, cooling, and shear tables, and not infrequently with supplementary transfer tables, so that, when the plate arrives at the shear table, it is cool enough for the markers-off. Hence no delay is experienced from the slab to the finished and sheared plate.

Finishing Mills.—In quite the larger number of mills engaged on iron or steel, the finishing mill is the principal manufacturing element. As the author naively remarks, the ideal finishing mill is that one which for the least investment will produce the greatest output at the smallest cost. At the present time, the nearest aproach to this ideal is found in the American rod mill.

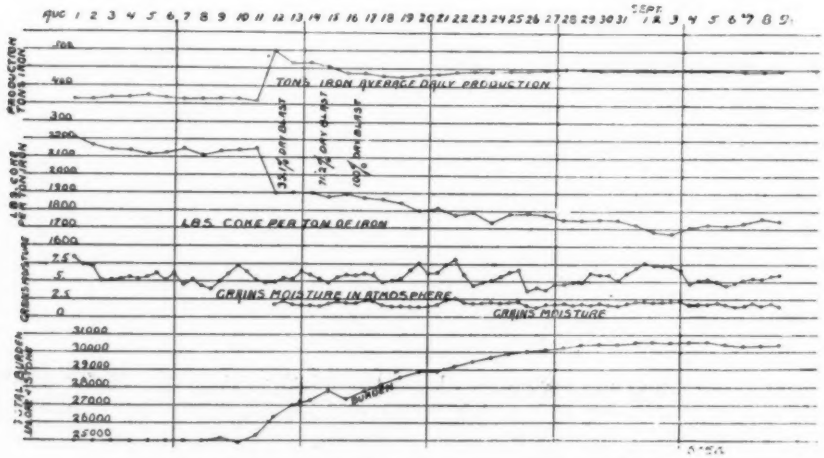
Blast Furnace Practice.

On the Application of Dry Air Blast to the Manufacture of Iron.—This process was briefly noted in our November issue, and it will be remembered that the moisture is removed by refrigeration, anhydrous ammonia being the cooling agent employed. In a most complete memoir, Mr. J. Gayley* gives further details and to some extent indicates the advantages of dry air blast. The evil influence of a leaking tuyere is familiar, yet the quantity of water then introduced is not greatly in excess of the amount carried into the furnace during a period of average humidity. The atmospheric moisture line on the accompanying chart shows the extent of variations over a comparatively short period. Figures quoted by Mr. Gayley show the variation over long periods to be comparatively great, and not unnaturally leads to variation in working the furnace. In other words, a high moisture content in the blast means a decreased burden or its equivalent—a higher fuel consumption. Turning again to the diagram, the advantages of dry blast are shown in the increased output and reduction of coke consumption corresponding to the increased burden.

Notes on the Blast Furnace.†—In these notes Mr. J. M. Hartman dwells on various details of the working of a blast furnace. In his opinion, irregularities in quality are largely due to unreduced ore and limestone in the form of large lumps which the furnace has not had time to reduce. As crushing can be

* American Meeting of the Iron and Steel Institute.

† *The Iron Trade Review.* Vol. xxxvii., No. 45.



THE APPLICATION OF DRY AIR BLAST TO THE MANUFACTURE OF IRON.

done mechanically at a low cost, both ore and limestone should be reduced to ¾ in. cube, thereby insuring better fuel consumption and a more regular product. In view of the importance of equal blast distribution a differential gauge is advocated in order that choked tuyeres may be detected and rectified.

Foundry Practice.

At the November meeting* of the New England Foundrymen's Association two papers on the chemical side of foundry practice were presented by Mr. H. E. Field and Dr. Moldenke respectively. Mr. Field, in treating of the "Chemistry of Cast Iron," reviews the influence of its various constituents, specially emphasizing the role of carbon. Thus, in the molten state, cast iron may be regarded as a solution of carbon in iron, whilst in the solid condition soft iron is a mixture of graphitic carbon and iron, the transition from dissolved to free carbon accounting for the utility of cast iron. Graphite itself gives softness to the iron, whilst the latent heat given off by the separation imparts fluidity, and the expansion also due to this separation results in a low shrinkage.

The second paper by Dr. Moldenke treats very lucidly of "Chemistry in the Foundry," indicating its practical value and offering some timely advice, which, summarized, reads:—"Apply chemistry intelligently." Not a mere analyst is wanted, but rather one who can apply his analyses to the work in hand without disorganizing the establishment. In concluding, the author says:—"We Americans are said to appropriate every good idea we find on the other side of the water, and so we have taken Professor Turner's discovery of the action of silicon on the carbon in cast iron. We have taken Profesor Ledebur's studies of carbon in the malleable casting, and have pushed these enquries far ahead in connection with our daily work. It is gratifying to see that England and Germany are awakening to the importance of the chemistry of cast iron, and foundrymen's associations are being called into life whose primary object is to study advanced methods of working. We wish them all possible success, and hope that their transactions may contain much new material that we can appropriate and apply later on. A rivalry which means the freest interchange of information is a detriment to no one, and stimulates research as well as commercial enterprise."

* *The Iron Trade Review*. Vol. xxxvii., No. 46.

General.

The Zinc Smelting Industry of the Western States.[1]—Statistics of the zinc production of the Western States are given, and a *résumé* of the development of the smelting industry. Most of the ore mined is blende or sulphide, hence a preliminary roasting is necessary. This roasting is effected in various types of furnaces, the old hand rabbling reverberatory ones being still used to some extent. The Hegeler muffle type of mechanically-rabbled furnace, in which the evolved sulphur is collected, is used in those works having an outlet for the resultant sulphuric acid.[2] In smelting, distillation is still followed, all attempt at direct melting having resulted in failure. First attempts at gas firing resulted in the Hegeler blow furnace, which, as now built, consists of a large rectangular chamber having retorts placed four rows high. Producer gas enters at one end of the chamber, the necessary air being introduced through iron pipes at suitable intervals in the chamber. No regeneration of gas or air is attempted, but the escaping hot gases are utilised for generating steam for power. Efforts have been made to apply the Siemens furnace, but the high cost of construction and, in many cases, faulty design have given the furnace a bad name—a prejudice which resulted in a reversion to the old style of direct fired furnace. These furnaces are cheaply constructed, give good average results, though at a high fuel and labour cost. Various difficulties encountered in the application of natural gas are recited, a solution being finally found by admitting gas and air at several points rather than gas only at one port.

[1] Mr. H. A. Meister, St. Louis Meeting, A.I.M., and *Mining World*, Vol. xxi., No. 20.

[2] See also "Hedburg's Simplex Process," page 365, November issue.

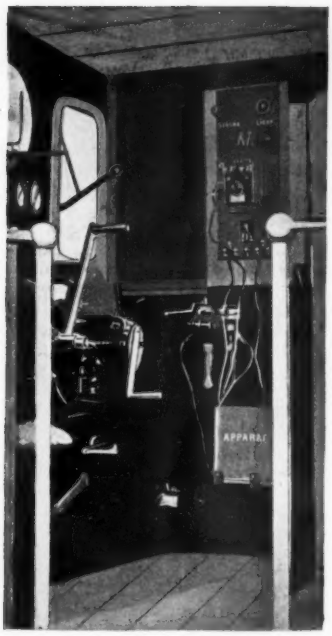
RAILWAY NOTES.

New German Engine Cab Signalling System.

A NEW system has recently been devised by the German engineers, Herren Hubert Pfirmann and Wendorf, of Frankfort a/M., Germany, for the protection of trains by engine cab signalling. The accompanying illustrations show the apparatus and contact rail used in this system of audible signals in the locomotive cab as installed by the Gesellschaft für Eisenbahn Zugdeckung. As will be noted, the track construction is provided with a third rail very much smaller than the running rails, and the engines are provided with current collectors or brushes running against the third rail, located in this instance between the tracks. The current collectors are connected with the axles and the running rails through a battery and relay, which closes a local circuit in the engine cab when the intensity of the current reaches a predetermined limit. The closing of this local circuit operates a lamp signal, a gong or the braking apparatus.

In this manner it is possible for the driver to be warned of danger caused by an open switch. Under ordinary conditions the coils of the relay are not excited, the circuit of the battery on the engine being open in its normal condition. A short circuit is made between the running rail and the live third rail if a switch is open, and in case a train passes on to this section of track the battery and relay circuit is closed by the running rails and third rail, which are thus electrically connected by the open switch. The signal will not be given at once, as the armature of the relay shown in the accompanying illustration of the safety apparatus in the locomotive cab will not be attracted until the distance from the signal where the rails are connected is such that the intensity of the current is sufficient to close the local circuit. A resistance coil of several ohms is connected with the live rail at distances of between 300 and 400 feet. When the locomotive reaches a distance from the open switch such that the resistance of these coils together with the rails has fallen to a predetermined value, the current passing through the relay reaches the proper amount to attract the armature, and the local circuit is closed, giving the audible or visible signal in the engine cab, or applying the brakes according to the arrangement thought best suitable to the conditions. The system has been installed on several miles of the German State Railway system, and is said to be operating successfully. The system also includes provision for the driver on one train communicating by telephone with the driver on another train. In order that there be no failure of the automatic signalling due to the apparatus on two trains opposing each other, by the batteries being connected in series or in opposition, thus causing the relays in one case to fail to work, a commutator has been provided on the axles of the trains, so that the current is reversed periodically, and therefore the batteries will be in series or in opposition alternately, as the speed of the two trains is never likely to be the same. When a train stops the battery is

NEW SYSTEM OF PROTECTING TRAINS BY ENGINE CAB SIGNALS: [GERMAN TRACK CONSTRUCTION, SHOWING CONTACT RAIL.



VIEW OF APPARATUS IN ENGINE CAB.

disconnected and a connection is made from the centre rail through the relays with the axle. These connections are the same as though the open switch closed the circuit, and any train approaching a standing train would automatically give the alarm in both engine cabs. The system is said to be thoroughly practicable, and the possibility of one engineer communicating with another is certainly unique and most desirable.

The Construction of a Concrete Railway Viaduct.

THE viaduct in question is situated at Cannington, on the Axminster and Lyme Regis Light Railway, which now connects Lyme Regis with the Yeovil and Exeter line of the London and South-Western Railway. A brief description, compiled from notes taken on the spot, accompanied by full illustrations, appeared in a previous issue.* Quite recently, however, the resident engineers, Messrs. A. Wood-Hill and E. D. Pain, fully described the work in a paper before the Institution of Civil Engineers, of which the following is an extract :—

The viaduct consists of ten elliptical arches of 50 ft. span, its total length being 600 ft., width over spandrels 16 ft., maximum height to rail-level 92 ft., and gradient 1 in 80. It affords an example of the recent application of concrete to viaduct construction and to arches of somewhat large span. With the exception of the concrete blocks in the vertical faces of the arches, the work throughout is mass concrete.

The geological strata are greensand and blue lias clay. The foundations, originally designed for a pressure of 3½ tons per square foot, were enlarged to give pressures ranging from 1 ton to 3 tons per square foot.

The concrete used consisted of crushed flints and Portland cement, the crushing yielding sufficient grit to make the addition of sand unnecessary except in special cases. The concrete was hand-mixed, and for transporting this and other materials a cableway of 1,000 ft. span was erected across the valley, the piers being built without scaffolding.

The piers were carried up in rectangular lifts of diminishing size, instead of having a continuous batter, the lifts being 6 ft. deep. The concrete was deposited in wooden boxes of this depth, which were bolted up on the ground and hoisted into position. The work in all the piers was advanced as far as possible at the same rate.

Two rows of corbels were built in the top lift of the piers, to support the arch-centering. This consisted of four built ribs, the centre portion of which was tied by a framework, in the form of a Warren girder, supported in the middle by raking struts from the lower row of corbels. The ribs, including the lattice-work, were set in one piece, and four tie bolts were placed in the span to assist the piers in taking the thrust.

The faces of the arches were built in concrete blocks, of which two similar ones on opposite sides of the viaduct were set simultaneously by a rail attachment to the cableway; and by adjusting the chains attaching the blocks the latter were suspended at the angles required by their

* Vol. ix., pp. 343-349.

position in the arch. The blocks were keyed in advance of the mass concrete, in order that the adhesion of the latter to the toothing of the blocks might relieve the centres of some of the weight.

Expansion joints were formed through the arches, spandrels and parapets, and are found effective in giving play for expansion and contraction and any slight movement due to settlement. In turning the arches, the centering, although apparently light, was found to be sufficiently rigid, and the setting was facilitated by the ribs being made in one piece.

The settlement of the piers was for the most part fairly even, and, being adjusted as the work proceeded, did not affect the concrete; but the settlement of the west abutment and first pier was greater than elsewhere, and crushed the crown of the first arch. Two diaphragm-walls were built in brickwork in cement in the third span, to enable it to act as an abutment, and concrete needles were built in the embankment between the first and second piers; the crushed portion of the first arch was cut out and made good in brickwork, and the parapets over this arch were completed.*

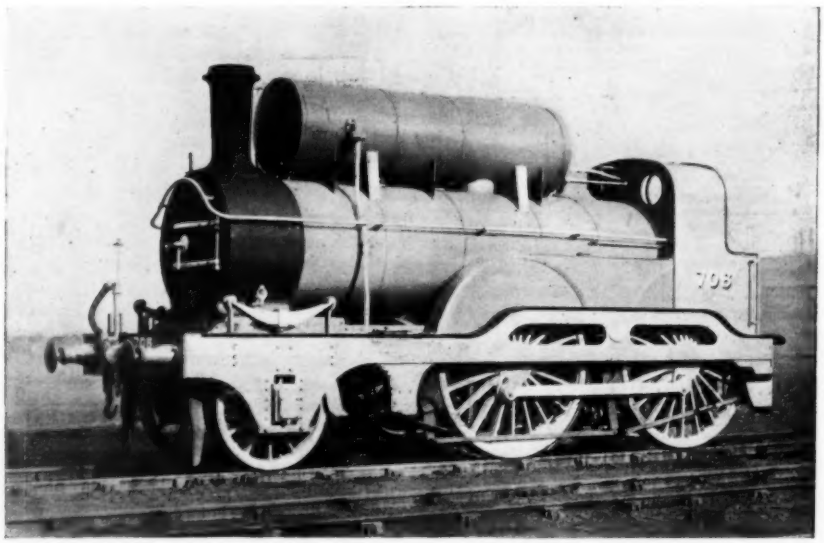
* *Cf.* drawing accompanying previous article.

The Authors believe this is the first instance in which piers of a similar height have been built without scaffolding, and in which the centres of a 50-foot arch have been designed for setting in one piece.

Thermal Storage on Locomotives.

MR. DRUITT HALPIN'S system of Thermal Storage as applied to steam boilers for stationary engines has, in certain circumstances, shown itself to possess distinct advantages over ordinary methods of boiler feeding. Professor Unwin's test conducted with Cornish boilers showed a coal saving of 19·7 per cent., and a second series of tests made at the generating station of the Kensington and Notting Hill Electric Light Co. showed that the evaporative efficiency of the boilers to which the apparatus had been applied was increased by 108 per cent., and that a small economy in fuel consumption was also effected.* In view of ascertaining the increased efficiency, if any, due to the application of the system to locomotives, Mr. Ivatt, of the Great Northern Railway, has fitted one of the old

* *Cf.* Vol. xi., pp. 1-2.



GREAT NORTHERN PASSENGER LOCOMOTIVE FITTED WITH HALPIN'S THERMAL STORAGE APPARATUS.

2-4-0 type passenger engines with the Halpin apparatus, the engine so fitted being shown in the accompanying illustration. The arrangement is very simple, and consists of a cylindrical storage tank placed above and connected to the boiler by means of a pipe. All the feed water, which is maintained at or about the same temperature as the water in the boiler, is passed through the cylinder, the water being heated by steam generated during the intermittent periods when the engine is standing or the safety valves are blowing. The water thus heated is fed to the boiler as required when the engine is running, this being regulated by a valve in the driver's cab. The tank is filled by injectors in the usual way, and it can be filled nearly to the top without danger of overflowing. A water gauge on the end shows the height of the water in the tank. Mr. Ivatt is, as yet, not in a position to furnish any information as to the results so far obtained, but there can be scarcely any doubt that the adoption of the apparatus will result in an increased evaporative efficiency, if not of fuel economy, as in the case of the stationary engine installations referred to above.

The Advantages of 4-Cylinder Compound Locomotive.

THE advantages of the 4-cylinder compound system were admirably dealt with in a paper by M. Sauvage, presented before the International Engineering Congress at St. Louis. The points made by the author may be summed up as follows:—

Economy of coal resulting from the compound system in itself, or increase of power with the same consumption of coal; good utilization of steam at very high pressure, with the simple or piston valve and the old gears; good balance of pistons and other pieces with reciprocating motion; counterweights applied only for revolving parts, thus doing away with vertical variations of pressure and pounding action on rails; ample bearing surfaces for all parts of mechanism, owing to the use of four cylinders with four separate gears and suppression of all undue strains.

In the Paris-Orleans experiments an average steam consumption of 10.5 kg. (23 lb.) per horse-power hour (the power being calculated from the action exerted by the driving wheels on the rail, to compare precisely with what is called the effective power of a stationary engine) has been measured with trains of heavy and also moderate weight.

As regards details of construction, the nearly exclusive use of Serve or ribbed tubes in all new constructions is well worth mentioning. Experiments have proved that the efficiency of a given surface of Serve tubes, taking into account the whole metallic area in contact with hot gases, was about the same as with the same surface of plain tubes; and in practice these tubes have been found durable and free from leakage.

For valve gears the Walschaert system has been extensively adopted. This system is quite convenient when the valve is placed above or under the cylinder, and there is an advantage in the use of one eccentric instead of two. The whole mechanism is simple and easily kept in order. The distribution of steam effected by the Walschaert system is particularly good, and quite uniform on both sides of the piston at different points of cut-off.

Piston valves are used in some of the latest designs. After the experience of the Eastern, they are preferable to flat valves, chiefly as giving larger ports and so reducing wire-drawing and compression of steam. An economy of coal, as high as 10 per cent., has resulted from their use in some cases.

Under the conditions of service prevailing on main French lines, it is rather under-estimating the merits of the compounds to say that by their use the weight of trains is increased by one-third with the same cost of fuel over what it was with the best simple engines used before; or, if not the weight, speed is increased, and in many cases both weight and speed.

The initial cost of the compounds is higher, the expenses for repairs somewhat greater, but the increase of traffic is such that the economy is obvious.

A complete solution of the problem would require a proof that the same results might not be obtained in some other way. Available data are not sufficient to give such a proof in an incontestable manner; still, it seems difficult to build an ordinary locomotive quite equal in every respect to the latest compounds.

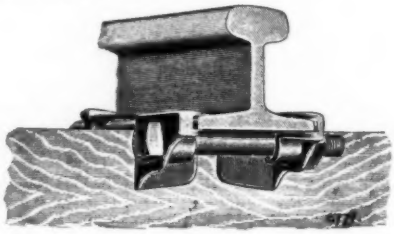
It is clear that simple two-cylinder engines might be made with the same large boiler, and work with the same high-pressure, but it is nearly as clear that, with the ordinary valve gear of the locomotive, steam at such a high pressure cannot be utilized as well as by compounding; there is little doubt that the simple locomotive would require more steam for the same work. In addition, there is a real difficulty in making all

the parts of the simple engine strong enough to stand without undue wear the greatest stresses resulting from the increased pressure on large pistons, although this difficulty may be overcome.

An opinion which seems to prevail is that compound locomotives may be economical during long runs, but that their advantage is lost when they stop and start frequently, owing to the direct admission of steam to the low-pressure cylinders at starting. This opinion is rather too dogmatic, and the question requires some consideration. In many cases, with four-cylinder compounds, the tractive power necessary for starting from rest is obtained without this direct admission, or steam is admitted in that way only for the very first revolution of wheels. The engine is then worked compound, but in full gear for all cylinders. Of course, steam is not so well utilized as with a proper degree of expansion in each cylinder, but, even in that case, the compound compares favourably with a simple locomotive working in full gear.

A New Rail Anchor.

CONSIDERABLE trouble is frequently experienced by the creeping of rails which results on double lines from trains running in one direction only on each pair of rails. The friction or push thus set up on the rails is continuous in one direction, instead of being equalised as would be the case if trains ran in opposite directions as on a single track. This fact has made it necessary to provide some means of preventing rails from creeping on the sleepers on even level stretches, and more particularly so on inclines where the rails creep to the lowest point from both directions, causing trouble to the permanent way men. Numerous devices have been tried to overcome this difficulty, one of the latest being the rail anchor recently introduced by the Holland Company, of Chicago, and which is shown in the accompanying illustration. The anchor is constructed with two malleable iron castings in the form of jaws which engage the lower flange of the rail. They are drawn together with one bolt, and extend below the rail and brace against the tie for nearly the entire distance under the rail. In the jaws are corrugated pieces of metal, which cut into the rail when the bolt is tightened, thus holding the rail securely. To hold the rails to gauge, a long bolt may be fitted from one rail to the other. The anchors are made to fit any size rail by simply using a longer or shorter bolt. From 12 to 20 sets of anchors—that is 6 to 10 to each rail—are required to prevent creeping at crossings, points, approaches to bridges, and at other places where rails are likely to jamb together.



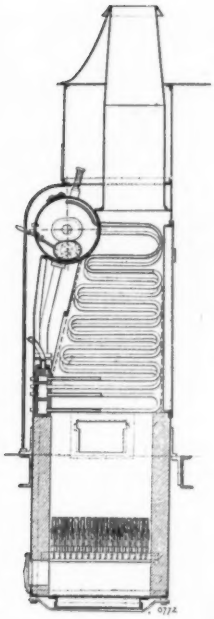
A NEW RAIL ANCHOR.

Steam Motor Carriage on the Northern Railway of France.*

A RATHER original type of steam carriage was put in service some years ago by the Northern Railway of France. This carriage, which works in either direction indifferently, is composed actually of three distinct sections coupled together, the motor section, placed in the middle and carrying the boiler, water tanks and a luggage compartment, and a passenger carriage at each end. Each of these sections is carried on two axles. The whole weighs 47 tons and measures 26·2 metres in length (77·54 ft.) The motor section alone weighs 20 tons; one of its axles is driven by a two-cylinder compound engine, the diameter of the cylinders being 195 and 280 mms., and the stroke 320 mms. The diameter of the wheels is 1·04 metres. The boiler, with water tubes of the Turgan system, has a heating surface of 30 sq. metres, a grate area of ·80 sq. metre, and a working pressure of 18 kgms. per sq. cm. The engineman manages the carriage alone. This carriage, which will carry 60 passengers, will mount a continuous gradient of 5 ft. in 1,000, at a rate of 55 kms. per hour. But its fuel consumption, which, on an average, is 7·7 kgms. per km., is relatively high, which appears primarily to be due to the insufficient size of the boiler.

Under its present form this system has not been more advantageous than the use of light locomotives. The Northern Rail-

* *Railway Age*, November 11th, 1904.



DETAILS OF THE PURREY BOILER.

way, consequently, has just undertaken new experiments by substituting for the present motor section one comprising a boiler and a motor on the Purrey system, the characteristic element of which is the boiler. This boiler, which works under an effective pressure of 20 kgms. per sq. cm., is composed of an upper reservoir of cylindrical form of sheet steel and of a lower collector of cast iron, of prism form and divided into three compartments. Two large steel tubes of 40 to 50 mms. diameter connect the lower part of the reservoir with the lower part of the collector. The latter compartment communicates with the com partment located immediately above by a series of U-shaped tubes, also of steel, of from 15 to 20 mms. diameter. Finally, two series of tubes analogous to those just described, but in serpentine form, afford communication, first, between the middle part of the collector and the middle part of the upper reservoir, and, second, between the upper part of the collector and the upper part of the reservoir.

Feeding takes place in the lower part of the collector, and steam is taken in the upper part of the same. A float, placed in a cylindrical reservoir, regulates automatically the working of the feed pump. This boiler, which produces superheated steam, and whose serpentine tubes contain, some a mixture of water and steam, and the others steam alone, is not provided with a gauge.

Coke is used for fuel, and this descends automatically upon the grate, which is in a manner a prolongation of the bottom of the hopper, inclined at an angle of about 30 degs. to the horizontal. The heating surface is about 26 sq. metres and the surface about ·84 sq. metre.

The motor apparatus is composed of four cylinders, mounted in pairs, tandem, and working compound with invariable cut-off The valves are operated by flexible stems to diminish the number of joints, and consequently reduce the complication of parts. This entire mechanism is attached below the frame of the carriage in the rear of the boiler, the whole being protected against dust by a sheet iron covering The part of this covering which surrounds the rod ends and eccentrics forms a receptacle which is half filled with oil to ensure proper lubrication.

At both extremities of the motor shaft are secured sprockets, which transmit the movement of the shaft by means of chains to one of the axles of the carriage, to which sprockets are also secured. The ratio of the diameter of these sprockets to those of the crank shaft is 1·566. The cylinders have diameters of 140 and 200 mms., respectively, and the stroke of the pistons is 200 mms.

Tests made with these vehicles have shown they can haul three light carriages, weighing 8 tons each, and maintaining an average speed of 5·5 kms. per hour, or four carriages at a rate of 50 kms. per hour. Without trailer, or even with a single trailer of 8 tons, a speed of 60 kms. per hour can be obtained. Upon grades of 15 in 1,000, with one or two trail cars, a speed of from 30 to 40 kms. per hour can be obtained.

The consumption of fuel is very light; it varies from 3 to 4 kgms per km., with ordinary gas coke. The consumption of water varies from 4·3 litres to 4·4 litres per kgm. of coke burned.

ABSTRACTS.

A Twist Drill Dynamometer.

By Wm. W. Bird and Howard P. Fairfield.

Proceedings of the American Society of Mechanical Engineers, Dec., 19 4

The introduction of the high speed twist drill into modern machine shop practice has brought with it many new problems, and to supply some of the data necessary for their solution the machine which is the subject of this paper was designed and constructed.

The machine is really a double dynamometer, measuring the twist or moment and the thrust of the drill. A view is given of the machine in Fig. 1, which shows the actual arrangements of the parts during the tests. It consists of a chuck with trunnions mounted on roller bearings so that it is free to revolve about its axis at the same time it is free to move in the direction of its axis, being mounted on a carriage which is on rolls resting on the frame of the machine. This frame was placed on the table of a milling machine so that the axis coincided with the centre line of the drill, which was driven by the spindle of the milling machine. The thrust of the drill is transmitted through the trunnion of the chuck to a plunger which is fitted into a long cylinder filled with oil. At the end of this cylinder is a smaller one, also carrying a plunger. This small plunger is attached to a ball-bearing piston in a regular indicator. The drum of the indicator moves proportionately to the feed, so that the card taken is a record of the thrust during the drilling of a hole. The chuck is held from turning by a steel hand, which is attached by a yoke to a second indicator, and a card from this one shows the twisting moment at each stage of the operation.

The correct moments were obtained by hanging known weights over the chuck and noting the rise and fall of the pencil point. The thrust cylinder was placed in an Emery testing machine, and known loads applied and a corresponding record taken on the cards. From these tests, curves were plotted so that readings from the cards could be readily reduced to pounds.

It was decided to take up first the drilling of cast iron with high speed steel. Blocks of soft gray iron were obtained and tested in the machine itself, so as to get a number for each set of experiments as near the same degree of hardness as possible. A 5/8 in. Novo steel drill was taken.

The first experiments were on the effect of speed or number of revolutions per minute, all other conditions remaining the same. The revolutions were varied from 140 to 600, but no material difference was shown by the cards in either thrust or twist. In other words, the power required to turn the drill varies directly with the number of revolutions, while the thrust does not increase with the speed, but depends upon the feed per revolution.

The next set of experiments was made to determine the relation between thrust and feed, the revolutions per minute remaining constant. From the first set of experiments it was shown that the limit of speed would depend upon the endurance of the drill, and with heavy feeds 420 revolutions was not far

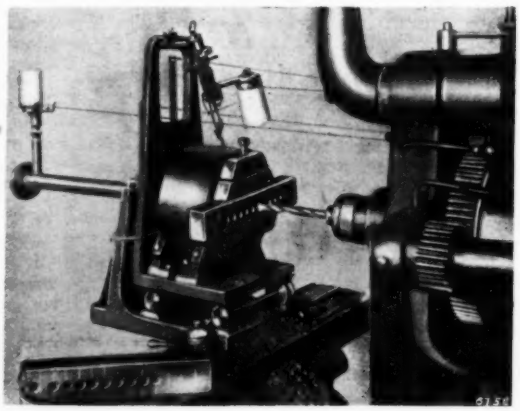


FIG. 1.

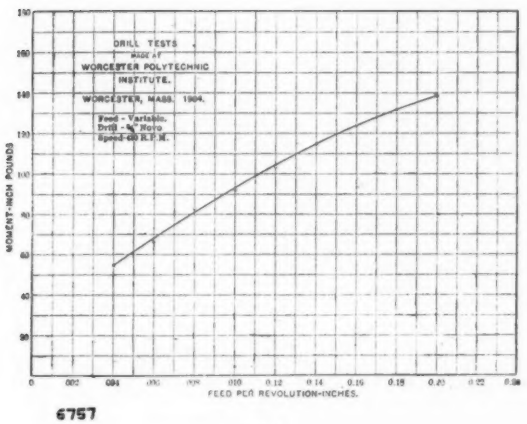


FIG. 2.

from this limit. Accordingly the second set was run at this speed, which, for a ⅝ in. drill is about 70 ft. per minute for the cutting rate for the outer edges, and for .020 in. feed a rate of drilling of about 8 in. per minute.

The range of feed was taken from .004 to .020 in. per revolution, the drill at the coarsest feed being somewhere near its limit. These feeds were all positive, a train of gears being substituted for the regular belt drive. The following table shows the results :—

Feed—inches per revolution :—

.004 .006 .008 .010 .012 .014 .016 .018 .020

Thrust—total in pounds :—

240 280 330 360 410 460 525 620 725

Moment—total in inch-pounds :—

55 67 83 92 103 115 124 132 138

Fig. 2 is a curve giving the relation between moment and feed, and shows that the moment does not increase at the same rate as the thrust. This would seem to indicate that less power is required to drill a given hole in a given time by increasing the feed per revolution rather than by increasing the revolutions.

The question of the proper angle of the drill was next considered, and a set of experiments made with a constant speed and feed, the half-angle varying from 37 deg. to 70 deg.—22 deg. less and 11 deg. more than the standard, 59 deg. The following table shows the results :—

Angle of drill :—

37 45 50 55 59 65 70 deg.

Thrust in pounds :—

215 225 240 260 290 325 375

A curve plotted from same shows that the thrust would be decreased by having more of a point on the drill. With an angle of 37 deg., however, the drill would not stand up on repeated work. At 45 deg. it seems to do the work as well as at 59 deg., and with much less thrust. This would suggest a change in the standard angle for the new steels. The moment for the various angles remained practically constant, so that the driving power does not change with the angles of the drill.

Another interesting point in drilling which can be shown with this machine is the effect of first removing the centre of the hole by the use of a small drill. Ten holes were drilled in a bar of cast iron with small drills, ranging from No. 53 to ½ in. in diameter, and then each one counterbored with a ⅝ in. drill at 420 revolutions per minute and a feed of .008 in. per revolution.

Table 3 gives the thrust in each case and shows that a hole $\frac{1}{16}$ in. in diameter takes off about one-half the thrust for a $\frac{5}{8}$ in.

Size of first hole :—

.000 .0595 .0760 .0935 .120 .157 .189 .221 .250 .375 .50

Thrust for counterbore :—

340 190 180 170 155 145 130 120 90 70 30

A New Hydraulic Experiment.

By A. F. NAGLE.

Proceedings of the American Society of Mechanical Engineers, December, 1904.

THE determination is that of the rise of water in a standpipe having a long supply pipe, when the draft suddenly ceases. In the case of the standpipe supplied by a long pipe, or tunnel, from a distant reservoir, and from which standpipe pumping engines are supplied, the question of how high the water will rise in the said standpipe, if the engines should suddenly cease to operate, is one on which there has been much discussion. To simply set at rest a preconceived notion that under no conditions could the water rise above its original

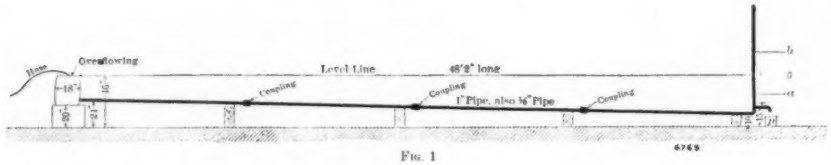


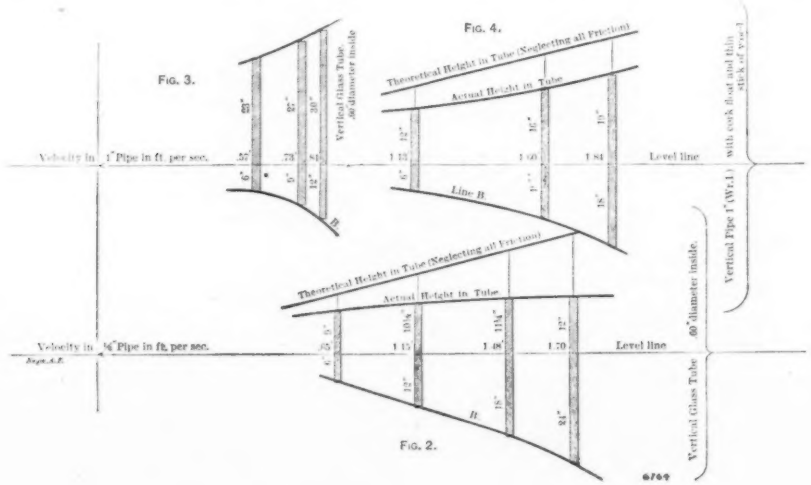
FIG. 1

level in the reservoir, the author made several experiments. The apparatus is shown in Fig. 1. It consists of an ordinary oil barrel, kept full to overflowing with water from a hose, the surface of the water in the barrel being kept 46 in. above the floor. First, a ½ in. wrought-iron pipe, 48 ft. 2 in. long, containing three couplings, was run to within 10 in. of the floor, followed by an ordinary cast-iron elbow and vertical riser. In this riser and 5 in. above the pipe, a cast-iron T was inserted, on the side of which T a common bib-cock was attached for drawing water into the pail. Above the T was attached an ordinary glass water tube, ·60 in. internal diameter.

When the water had come to rest, an elastic was placed on the glass tube to mark the position of the level line. Another elastic was set 24 in. below the level line, and the bib-cock was opened and adjusted until the water was drawn down to it and a constant flow established. The cock was fixed, with the water in the tube at this lower position, and the water escaping under these conditions was then taken up in pails and weighed each minute. Then the bib-cock was closed suddenly and the rise of water in the glass above the level line was noted. Experiments of a like nature were made with the water under constant flows and at levels in the glass tube of 18 in., 12 in. and 6 respectively below the level line. The results given in the paper are plotted in Fig. 2. Another experiment consisted in substituting an inch wrought-iron vertical pipe for the small glass tube, and also putting in a full inch plug-cock for the smaller ½ in. bib-cock. The results given are plotted in Fig. 4. A careful study of the values of the coefficients of friction, z, does not indicate any material difference due to different velocities. Grouping them together we have

Velocity	1·84 ft. per sec.	1 in. pipe,	z	=	·04250
,,	1·70	,, ½ ,,		=	·03913
,,	1·00	,, 1 ,,		=	·03620
,,	1·48	,, ½ ,,		=	·03863
,,	1·15	,, ½ ,,		=	·04353
,,	1·13	,, 1 ,,		=	·03620
,,	·85	,, ½ ,,		=	·03910
Averages	1·39				·03933

Is it possible to deduce a formula from the above data applicable to the general problem? The theoretical formula, ignoring friction or other losses, and when the standpipe is of the



same diameter as the main supply pipe or tunnel, is very simple. In that case the residual energy of the water in the long pipe must be absorbed by the work done in lifting a column of water in the standpipe to a mean height of one-half its own height. This would be expressed by the formula

$$L \times h = X \times \frac{X}{2}$$

where L = length of pipe or tunnel,

h = head due to velocity = $\frac{V^2}{2g}$

X = rise in standpipe above level of reservoir.

This equation can be expressed as

$$X = \sqrt{2Lh};$$

or substituting the value of h in terms of v, we have

$$X = 0{\cdot}176\, v\, \sqrt{L}.$$

Applying the formula to the experiments, and taking $L = 49$ ft. $\sqrt{L} = 7$ ft., the values for X are found

These values of X are plotted in Figs. 2 and 4, and reveal the difficulty of constructing a formula which will give results fitting the experiments noted. It is, perhaps, reasonable that in the case of the smaller pipe the greater deviation from the theoretical rise should be found, but the indications are that in the larger sizes the rise will approach close to the theoretical height. To illustrate the application of the formula. Assume a 7-ft. diameter tunnel, 24,000 ft. long, supplying 100 million gallons of water per 24 hours, causing a velocity of 4 ft. per second. If the standpipe is of the same diameter as the tunnel, the theoretical height to which the water may rise will be $.176 \times 4 \times \sqrt{24{,}000} = .704 \times 155 = 109$ ft. Should the standpipe be enlarged to 12 ft. diameter, the equivalent height to which the water will rise can be found by the formula.

$$d^2 \times h \times \frac{h}{2} = D^2 \times H \times \frac{H}{2} \text{ or } d \times h = D \times H$$

where d = original diameter of pipe,

h = height of column as found by equation,

D = enlarged diameter,

H = height in enlarged pipe.

Making these substitutions we have

$$7 \times 109 = 12 \times H \text{ or}$$

$$H = 64 \text{ ft.}$$

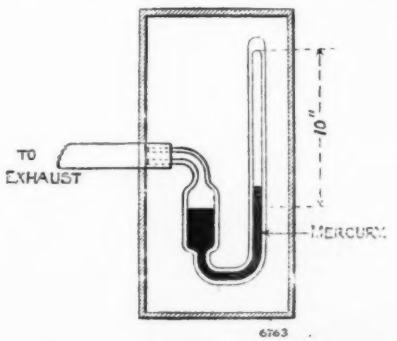
The Measurement of Vacuum.

By C. TURNBULL.

Proceedings of the Institution of Electrical Engineers (Newcastle Section), Dec. 12th, 1904.

THE author directs attention in his paper to the measurement of vacuum, which at present is obtained in a most unsatisfactory and indirect manner. The vacuum gauge in common use measures the difference between the condenser pressure and the atmospheric pressure. It is, therefore, necessary to read the barometer as well as the vacuum gauge to get at the true result. Thus, with a vacuum gauge at 25 in. and the barometer at 30 in., the actual pressure of the condenser is 5 in., and this 5 in. is the only quantity that really concerns us. What we require is an instrument which will fulfil the following requirements:—(1) It must show the actual pressure in the condenser quite independently of the pressure of the atmosphere; (2) it must be quite accurate in its readings, and not liable to go wrong.

The first requirement would be met by an ordinary Bourdon gauge with an *exhausted tube* (or a similar arrangement to that used in the aneroid barometer), but with the *case* of the instrument connected to the condenser. This will measure the actual pressure at the exhaust, quite independently of the pressure of the atmosphere. Another and perhaps better way is to make use of the ordinary mercury barometer, only it must be connected up properly. Connected up as in Fig. 1, the mercury column will show simply the actual pressure in the condenser, and quite accurately. When the mercury rises 4 in. in the tube, it means just that there is a pressure in the condenser which has an effect upon the back of the piston of a reciprocating engine as if the piston were lifting a layer of mercury 4 in. deep. The author thinks that this concrete idea helps us to understand the reality of the stuff left in a 26 in. vacuum, and how it is that good



work may be got out of this stuff if it is allowed to flow into a still lower pressure. For most purposes with the instrument, a 10 in. tube is quite long enough, for this will show a vacuum as low as 20 in. The instrument can therefore be made in a neat and cheap form. Whether or no it would be better to speak of a 29 in. vacuum as being a 1 in. back pressure, time alone will show.

Position of Gauge.—It is to be noted that the reading of any vacuum gauge is materially altered by its position. If it be placed low down, then water will collect in the tube leading to it, and the weight of the column of water will affect the reading. Probably this fact often accounts for the difference of reading between the gauge on the engine exhaust pipe and the gauge on the condenser, as much as the drop of pressure between the two due to loss in the connecting pipes.

Tar Oils for Oils Firing.

By M. A. RISPLER.

Journal of Gas Lighting, November 15th, 1904.

THE author says that, at a time when so much is heard about heating with petroleum, it is appropriate to discuss also the use of tar oils for this purpose. Though these oils have been applied for many years, the results obtained with them have commonly been kept quite secret. For instance, experiments have been tried with them in the Austrian Navy for heating the boilers of torpedo boats, where the high flashing point, 95 deg. to 105 deg. C., of the heavier tar oils gives them the advantage over the readily inflammable petroleum that in warfare they would be less likely to be ignited by exploding shells. In industrial works, and tar-works in particular, certain tar oils are frequently used as fuel.

M. Rispler goes on to discuss the financial aspect of the application of tar oils for heating purposes. On the large scale, and over a period of several months, it has been found that 100 lb. of tar oil are equivalent to 200 to 220 lb. of good screened coal. Thus the tar oil must not cost, per ton, more than 2 to 2.2 times as much as such coal, in order that it may be applicable for heating purposes. From this datum, anyone may calculate, on the basis of the prevailing cost of coal, how great a saving can be effected by the use of tar oils. The most essential condition of the economical utilization of tar oils as fuel is the use of a suitable fire-box. The chief advantage of liquid over solid fuel lies in the rational combustion of the former. The combustion of liquid fuels can be precisely regulated, whereas with solid fuel much is lost through the excess of air required and the lapses of the stokers.

The combustion of tar oils is effected by injecting them, by means of steam, through an atomizer, in a jet of very fine drops into the furnace, where they burn. The heat developed is very great, and thus the iron plates of the heated vessels suffer. With Cornish and Lancashire boilers, the tubular flues should be protected by a fire-brick lining as far as the flame penetrates. With stills, burning of the bottom plates is not so likely, as the bottom is usually protected by an arch or is dumped up so that the flame is spread out. The grate itself is done away with, being covered by a wrought or cast iron plate, which shuts off the ash-pit so that the air supply does not reach the flame from below. The air required for combustion must pass through holes in the furnace door direct to the atomizer, so that excess can be avoided and good combustion attained.

The general arrangement of apparatus for oil-firing, as described by M. Rispler, is that an oil-tank is placed about 5 ft. above the level of the atomizer. In this tank, which contains the store of oil, there is a steam coil of several turns, for maintaining the oil warm, so that any crystals are kept in solution. The steam-pipe passes out of the bottom of the tank, takes a turn through the fire box, and then enters the atomizer. The steam is super-heated and dried in the loop of the pipe in the fire box, and this ensures uniformity of combustion. There is a small cock on the steam pipe, just as it enters the atomizer, for blowing off condensed water when the furnace is being started. The oil passes through a pipe to the atomizer, which is set at a slight inclination towards the fire-plate, in order to avoid the points of flame impinging directly on the bottom plates of the still or boiler. There are openings in the furnace door, provided with dampers for controlling the air supply to the furnace, and valves for regulating the passage of steam and tar oil.

At starting, a wood or coal fire is lit in the fire-box, and steam is allowed to blow through the pipe and off at the condensation relief cock. As soon as the tar oil in the tank is warm and the steam is dry, this cock is shut, and the steam passes on to the atomizer, while the oil-valve is at the same time opened. The steam breaks up the

stream of oil, which ignites at the fire, and produces a long and powerful flame. The inflow of oil and steam is so regulated that the flame is not smoky. Once the oil is burning properly, nothing more has to be done except to regulate the supply of oil and steam to vary the size of the flame according to the immediate requirements.

Anthracene sludge can also be used by means of the arrangement described; but in order to avoid blocking of the oil-pipe through deposition of crystals, the steam-pipe is run close alongside the oil-pipe, and an insulating jacket is put around them, so that the oil-pipe is kept warm and crystallization prevented.

Air in Relation to Boiler Feed.

By J. A. SMITH.

Proceedings of the Victorian Institute of Engineers at Melbourne.

THE author recorded the results of a number of experiments he had conducted in a study of the capacity of water to absorb air under various conditions, with a view to the subsequent investigation of the corrosion of moist iron surfaces in the presence of air. His observations on the effects of the absorption of atmospheric components by comparatively pure water in relation to some engineering problems, such as oil oxidation and the operation of the superheater and of the air pump and condenser, are briefly stated in the following review:—

It has been deduced that, eliminating the carbon dioxide, the gases absorbed by a pure water from the air consist of oxygen and nitrogen mechanically mixed in the constant ratio of 34.91 parts of oxygen and 65.07 parts of nitrogen, while the corresponding proportions of these gases in ordinary air is 20.94 and 78.4 parts, respectively. Under no conditions of pressure or temperature can air be absorbed except as bubbles mechanically entrained and rapidly separating out. The gaseous mixture occupying the intermolecular spaces of the fluid differs from air; the oxidizing agent is largely increased. Ferric hydroxide is the result of the combination of oxygen with iron in the presenec of water. It may be shown arithmetically that each cubic inch of oxygen at atmospheric pressure and temperature is capable of reducing 0.84 gr. of iron to rust; or, in other words, free oxygen in each pound of atmospherically-saturated feed is potentially capable of dissolving 0.154 gr. of iron, equivalent to more than 1½ gr. per gallon. That complete saturation is ever approximated in practice is problematical; otherwise about ⅗ lb. of iron would be consumed for 1,000 h.p. hour.

Known facts relating to feed pipes, economizer tubes, and those parts of boilers near the inlet, amply prove, he said, that marked oxidation may ensue when the gases are released by temperature increment, and while they still continue in a constricted fluid flow, in contact with relatively large bounding superficies. Later, owing to the extreme tenuity of the gases when expelled into, and diffused through, the steam spaces, and swept forward by the vapour, the bulk of the atoms can never reach a corrodable surface.

Feed-waters containing mineral matter or bases might fix a portion of the free oxygen; the resulting salts, if insoluble, would precipitate as mud or scale. If soluble and corrosive, the free oxidizing agent would no longer be steam-swept from the system, but would remain to exercise its deleterious effects in the boiler. A pure feed-water, even distilled, may contain about ⅗ gr. of free oxygen per gallon.

Oil in the atomized state presents, in relation to its mass, very large superficies. Determinations of the absorptive power of mineral cylinder oils varies from 0.1 to 0.45 c.c. per gram.; the figures are greatly higher for animal and vegetable oils, or mixtures of these with mineral lubricants; therefore, free oxygen, in the quantities found in practice, may play a not inconsiderable part in the economy of steam lubrication. Possibly the difficulty of separating the emulsified oil from hot-well waters may be traced, in part, to isolation of particles consequent upon surface induration arising from the preceding cause.

The action of free oxygen is not wholly detrimental. The well-known method of dissociating water-gases by passing steam over heated iron borings is a case in point. The effect under superheater conditions is to form the black magnetic oxide, probably the most effective protection against further corrosion known. Fatty acids, produced as a step in oil-oxygen combinations, may still continue to corrode the tubes.

The existing wide discrepancies in air-pump proportions under not very different conditions of use are recognized as unsatisfactory. Whether accurate knowledge of the gaseous volumes will alone suffice for rectification of the equations is doubtful. The gaseous volume is relatively very small; the gases expelled from 1 lb. of cold feed do not exceed about 30 cub. in. (more in a jet condenser), when expanded until they exercise a partial pressure of ⅓ lb. absolute.

The Forcing Capacity of Fire Tube Boilers.

By F. W. Dean.

Proceedings of the American Society of Mechanical Engineers, December, 1904.

There is a widespread impression among many persons interested in boilers that the fire tube type of boiler has less capacity to be worked above its rated power than boilers of the water tube type, and that it is necessary to provide such power with more heating surface per horse-power than water tube boilers require. It is pointed out that it has been for many years customary to base the horse-power of horizontal return tubular boilers upon 15 sq. ft. of heating surface per horse-power, although at present some makers of this boiler venture to base it upon 12 sq. ft.

It is the object of the paper to show that the prevailing opinion upon the relative forcing capabilities of the two types of boiler is incorrect, and in support of this claim the author gives particulars of several boiler tests upon different kinds of fire tube boilers.

It may also be well to state what is meant by ability to stand forcing: it is the capacity to evaporate much more water than the rated power of the boiler would require. This amount is often 20, 50, or even 100 per cent. in excess of the rated requirements, and depends upon the amount of fuel consumed in a unit of time. This in turn depends chiefly upon the draught in the fire box and the freedom with which air can pass through the grate or stoker and through the fuel itself.

An alleged reason for the superiority is that the water tube boiler contains less water than the fire tube boiler, by which is meant that it contains less water in proportion to the heating surface. The author has computed that contained by several fire tube boilers, the results of which show that water tube boilers generally contain more water than horizontal fire tube boilers. It appears from this that whatever advantage accrues from small water contents lies with the horizontal return tubular boiler. The vertical water tube boiler, as well as some designs of fire tube boilers, contains more water than horizontal boilers.

A little consideration, however, will show that the quantity of water contained by a boiler has no effect upon forcing capacity after steam is once up to the working pressure. The reason for this is that heat added cannot raise the temperature of the water, and can, therefore, only increase the quantity of steam formed and increase the quantity and temperature of the escaping gases. It therefore appears that both types of boiler have equal merits in this respect.

Another claim is that as the flame enters among the tubes of water tube boilers the evaporation is forced more than if it did not reach them. As flame is combustion in process, and is likely to be prematurely terminated by contact with the relatively cold surfaces of the tubes, it is apparent that it is disadvantageous to have the flame pass among the tubes.

Another claim is that the hot gases impinge against water tubes and therefore give up much more heat than they would if they passed parallel to them. The fallacy of this argument is apparent when it is remembered that gases give up heat because their temperature is higher than that of the heat-receiving medium, and not because they are thrown against this medium. Moreover, some kinds of water tube boiler compel the gases to move parallel to the tubes, and this feature is held to be highly advantageous by interested persons. Incidentally, it will be found disadvantageous to project boiler gases against the outsides of tubes, for examination shows that it causes wedge shaped accumulations of soot at the very part of the tubes where the greatest reception of heat was expected, thus rendering this part the least effective of any.

It is also claimed that there is less reduction of draught between the smoke flue and the fire box in water tube than in fire tube boilers on account of larger spaces between the tubes of the former than through the tubes of the latter. In cases where the author has determined it the results are inconsistent and contradictory. He has found, however, that the vertical fire tube boiler requires the least draught for burning coal at a given rate. This, he thinks, is due to the path of the air being at right angles to the fuel and therefore shorter and less impeded by the fuel than with horizontal boilers, in which the path of the air is diagonally through the fire. In this connection, observe the slight draught found in some cases farther on.

Horizontal Return Tubular Boilers.—Referring to the results of trials, there were in 1894, at the Atlantic Mills, Lawrence, Mass., several horizontal return tubular boilers twenty-four years old, containing their original tubes, and which had never been cleaned on their water sides. The following are the general dimensions of each boiler:—

Diameter of shell	60	in.
Diameter of tubes	3½	in.
Length of tubes	20	ft.
Number of tubes	55	
Heating surface, fire sides	1,112	sq. ft
Grate area, 1st test, 21·77 sq. ft. ... 2nd test, 21·51		sq. ft

The author tested one of these boilers with the following general results :—

That a horse-power was obtained from 8 and 7.7 sq. ft. of heating surface, that 6.37 and 6.73 horse-power were obtained from each sq. ft. of grate, that 0.41 lb. and 0.42 lb. of coal were consumed per square foot of heating surface per hour, and that these results were obtained with not over ¼ in. of draught. These results are quite remarkable, especially as the economy was not very inferior, and especially considering the age of the boiler.

At the Cumberland Mills, Maine, there are six 90 in. horizontal return tubular boilers, each containing 4,027 sq. ft. of heating surface. When the first four were put in, two of them were equipped with Babcock & Wilcox chain grates and two with second-hand shaking grates for temporary use. The general dimensions are as follows :

Diameter of shell	90 in.
Diameter of tubes	3 in.
Length of tubes	20 ft.
Number of tubes	258
Heating surface, fire sides	4,027 sq. ft.
Grate area with chain grate stoker ...	61·87 sq. ft.
Grate area with hand fire grate ...	48·75 sq. ft.

The author tested one of the hand-fired boilers on April 4th, and one with the stoker on April 5th, 1900, with the following general results :—

	Hand.	Stoker.
Duration	9·5 hrs.	8·75 hrs.
Calorific value of coal by analysis	13,961 B.T.U.	
Average steam pressure	92·1 lbs.	94 lbs.
Force of draught in smoke box ...	0·90 in.	0·91 in.
Temperature of feed water ...	85·5 deg.	85·5 deg.
Temperature of escaping gases...	569 deg.	645 deg.
Dry coal consumed...	19,522 lbs.	20,351 lbs.
Per cent. of refuse in ash pit ...	8·27 p.c.	8·72 p.c.
Total water evaporated from and at 212 degrees	206,437 lbs.	223,983 lbs.
Water evaporated per pound of dry coal from and at 212 degrees	10·75 lbs.	11·06 lbs.
Water evaporated per pound of combustible from and at 212 degrees	11·53 lbs.	12·06 lbs.
Commercial horse-power... ...	630 h p.	742 h.p.
Horse-power per sq. ft. of grate...	12·92 h p.	12·00 h.p.
Heating surface per horse-power	6·39 sq.ft.	5·43sq.ft.
Dry coal burned per square foot of grate per hour	42·2 lbs.	37·6 lbs.
Dry coal burned per square foot of heating surface per hour ..	0·51 lbs.	0·58 lbs.
Water evaporated per square foot of heating surface per hour from and at 212 degrees ...	5·39 lbs.	6·35 lbs.

The rate of combustion, the temperature of the escaping gases, the small heating surface per horse-power, the amount of coal burned and the horse-power developed per square foot of grate, and the amount of coal burned and water evaporated per square foot of heating surface are truly remarkable and are seldom equalled. They show that this type of boiler is as well suited to forcing as any, and leave nothing to be desired.

Manning Vertical Boilers.—Two remarkable tests of these boilers, which were equipped with Roney stokers, were made at the mill of the Burgess Sulphite Fibre Co., Berlin, N.H., and of these one in which a draught of 1.28 in of water was used is unique. The general particulars are given below :—

Diameter of tubes	2½ in.
Number of tubes	384
Length of tubes	15 ft.
Water heating surface	2,498 sq. ft.
Superheating surface	895 sq. ft.
Inclined grate area of Roney stoker ...	52 sq. ft.

Results of Tests.

	Test No. 1.	Test No. 2.
Duration	24 hrs.	24 hrs.
Average steam pressure	107·9 lbs.	107·6 lbs.
Force of draught in flue	0·50 in.	1·28 in.
Temperature of feed water ...	39 0 deg.	39·6 deg.
Temperature of escaping gases...	742 deg.	695 deg.
Per cent. of CO_2 in gases... ...	11 p.c.	8·3 p c.
Dry coal consumed...	25,972 lbs.	47,866 lbs.
Dry coal consumed per hour ...	1,082 lbs.	1,994 lbs.
Per. cent. of refuse in ash pit ...	9·7 p.c.	7·2 p.c.
Water evaporated per hour from and at 212 degrees	11,700 lbs.	19,386 lbs.
Water evaporated per pound of dry coal from and at 212 degrees	10·81 lbs.	9·72 lbs.
Water evaporated per pound of combustible from and at 212 degrees	11·98 lbs.	10·48 lbs.
Rating of boiler	250 h.p.	250 h.p.
Commercial horse-power	339 h.p.	562 h.p.
Per cent. over rating	36 p.c.	125 p.c.
Horse-power per sq. ft. of grate...	6·25 h.p.	10·81 h.p.
Water heating surface per h.p. ...	7·37 sq.ft.	4·44sq.ft.
Dry coal burned per square foot of grate per hour...	20·81 lbs	38·34 lbs.
Dry coal burned per square foot of water heating surface per hour	0·43 lbs.	0·78 lbs.
Water evaporated per square foot of water heating surface per hour from and at 212 degrees...	4·68 lbs.	7·76 lbs.

The result of the second test is phenomenal. The economy is not good, but this is evidently due to the firing, as the CO_2 in the flue gases was low. The result, 4.44 sq. ft. of water-heating surface per horse-power, is extremely small, and the coal consumption per square foot of grate, the coal burned per square foot of heating surface, and the water evaporated per square foot of heating surface are remarkably large. The percentage of power above the rating is no less noticeable. The temperature of the gases is low, considering the coal consumed, although it would no doubt have been higher if the combustion had been better.

The Manning boiler has a very small water surface, and the ebullition during this test must have been tremendous. Nevertheless the steam left the boiler superheated 50 deg. ; that is to say, if moisture was in the steam as it escaped from the water surface, it was, by contact with the tubes, evaporated and superheated.

Corliss Vertical Boiler.—The author made tests of Corliss vertical boilers at the Narragansett Mills, Fall River, Mass., with the results given below :—

General Dimensions.

Diameter of shell	84 in.
Diameter of fire box	78½ in.
Height of fire box	5 ft.
Number of tubes	268
Diameter of tubes	2½ in.
Length of tubes	13 ft.
Grate surface	33·4 sq. ft.
Water heating surface	1,492 sq. ft.
Superheating surface	544 sq. ft.
Grates ... ... fixed and hand fired.	

Results of the Tests.

	No. 1.	No. 2.
Duration	10·87 hrs.	6·06 hrs.
Calorific value of coal by analysis	13,952 B.T.U	
Average steam pressure	115·93 lbs.	114·55 lbs.
Force of draught in smoke box	0·16 in.	0·19 in.
Temperature of feed water	106 deg.	103 deg.
Temperature of escaping gases	501 deg.	555 deg.
Superheat	39 deg.	54 deg.
Dry coal consumed	7,253 lbs.	4,241 lbs.
Per cent. of refuse in ash pit	5·89 p.c.	7·45 p.c.
Water evaporated per hour from and at 212 degrees	7,073 lbs.	7,370 lbs.
Water evaporated per pound of dry coal from and at 212 degrees	10·60 lbs.	10·43 lbs.
Water evaporated per pound of combustible from and at 212 degrees	11·27 lbs.	11·27 lbs.
Commercial horse-power rated	160 h.p.	160 h.p.
Commercial horse-power on test	205 h.p.	214 h.p.
Excess of h.-p. above rating	28 p.c.	34 p.c.
Horse-power per sq. ft. of grate	6 14 h.p.	6·41 h.p.
Water heating surface per h.p.	7 28 sq.ft.	6.97 sq.ft
Dry coal burned per square foot of grate per hour	20·00 lbs.	21·17 lbs.
Dry coal burned per square foot of water heating surface per hour	0·45 lbs.	0·43 lbs.
Water evaporated per square foot of water heating surface per hour from and at 212 degrees	4·66 lbs.	4·83 lbs.

Gunboat Boiler.—This is a type of horizontal fire tube boiler that in the Navy is called the Gunboat type. It consists of two cylindrical furnaces joining a combustion chamber, from which tubes pass to a smoke box at the farther end. There are four of these boilers at the Washington Mills. Two of them were tested simultaneously, the general results as applied to one being :—

Diameter of boiler	10 ft.
Diameter of furnaces	48 in.
Diameter of tubes	2½ in.
Length of tubes	14 ft.
Number of tubes	570
Heating surface, fire sides	5,300 sq. ft.
Grate area	60 sq. ft.

Results of Tests.

	Dec. 22, 1897
Duration	11·5 hrs.
Average steam pressure	122·3 lbs.
Force of draught in smoke box	0·875 in.
Temperature of feed water	36·7 deg.
Temperature of escaping gases	526 deg.
Dry coal consumed	21,842 lbs.
Per cent. of refuse in ash pit	9 28 p.c.
Total water evaporated from and at 212 degrees	247,173 lbs.
Water evaporated per pound of dry coal from and at 212 degrees	11·32 lbs.
Water evaporated per pound of combustible from and at 212 degrees	12·47 lbs.
Commercial horse-power	623 h.p.
Horse-power per square foot of grate	10·38 h.p.
Heating surface per horse-power	8·51 sq. ft.
Dry coal burned per square foot of grate per hour	31·66 lbs.
Dry coal burned per square foot of heating surface per hour	0·36 lbs.
Water evaporated per square foot of heating surface per hour from and at 212 degrees	4·05 lbs.

This is an instance of a high rate of combustion, and fairly high rate of evaporation per square foot of heating surface. These boilers were designed with a large heating surface in proportion to the grate surface (88 to 1), and the rate of evaporation was correspondingly low.

To pursue this subject a little farther, the greatest forcing in boiler performance is being performed constantly by the fire tube boilers of locomotives. It is common enough for a horse-power to be obtained from 2 sq. ft. of heating surface, or even less, and the horse-power per square foot of grate may vary from 20 to 40. In comparison with such performances, others are insignificant.

In the data here presented there are ample reasons for believing that the fire tube type of boiler is fully equal to any demand that may be made upon it, and the author is not aware of any evidence that the water tube type of boiler can surpass it in the respect which forms the subject of this paper.

Electrometallurgy of Iron and Steel.

Report published by the Department of the Interior of the Canadian Government.

The complete report of the commission appointed by the Canadian Government to investigate the different electrothermic processes for the smelting of iron ores and the making of steel in operation in Europe. The report contains first detailed descriptions by Haanel of the Kjellin, Heroult, Stassano, and Keller furnaces, with excellent photographs and detailed drawings of the furnaces; also shorter notes on the Harmet and Gin processes. Then follows the report of the electrician, C. E. Brown, giving details on the method of making the electrical measurements. He gives the following cost of electrical energy consumed in the various processes on the basis of the cost of $10 per h.p.-year. For the reduction of pig iron from ores the cost of electrical energy per metric ton of pig was $5.25 for the Heroult process and $5.30 and $2.50 for two runs of the Keller process. For making steel the cost of electrical energy per metric ton of ingot was $1.30 and $1.60 for two runs of the Kjellin process; $1.70, $1.70, $1.11 for three runs of the Heroult process, and $1.25 for the Keller process. This is followed by the report of the metallurgist, F. W. Harbord, who reaches the following conclusions:—Steel, equal in all respects to the best Sheffield crucible steel, can be produced, either by

the Kjellin or Heroult or Keller processes, at a cost considerably less than the cost of producing a high-class crucible steel. At present, structural steel, to compete with Siemens or Bessemer steel, cannot be economically produced in the electrical furnaces, and such furnaces can be used commercially for the production of only very high-class steel for special purposes. Speaking generally, the reactions in the electric smelting furnace as regards the reduction and combination of iron with silicon, sulphur, phosphorus, and manganese are similar to those taking place in the blast furnace. By altering the burden and regulating the temperature by varying the electric current, any grade of iron, grey or white, can be obtained, and the change from one grade to another is effected more rapidly than in the blast furnace. Grey pig iron, suitable in all respects for acid steel manufacture, either by Bessemer or Siemens processes, can be produced in the electric furnace. Grey pig iron, suitable for foundry purposes, can be readily produced. Pig iron low in silicon and sulphur, suitable either for the basic Bessemer or the basic Siemens process, can be produced, provided that the ore mixture contains oxide of manganese, and that a basic slag is maintained by suitable additions of lime. It has not been experimentally demonstrated, but from general considerations there is every reason to believe that pig iron low in silicon and sulphur can be produced even in the absence of manganese oxide in the iron mixture, provided a fluid and basic slag be maintained. Pig iron can be produced on a commercial scale, at a price to compete with the blast furnace, only when electric energy is very cheap and fuel very dear. On the basis taken in the report, with electric energy at $10 per electrical h.p.-year, and coke at $7 per ton, the cost of production is approximately the same as the cost of producing pig iron in a modern blast furnace Under ordinary conditions, where the blast furnaces are an established industry, electric smelting cannot compete; but in special cases, where ample water power is available, and blast furnace coke is not readily obtainable, electric smelting may be commercially successful. With respect to these conclusions of Harbord, the following remarks are made by Haanel. He agrees with everything that is said concerning the electric production of steel. In reference to the production of pig iron he points out that the results obtained at Livet were obtained in furnaces not specially designed for the production of pig iron from ores. With improved furnaces, better results can be obtained. "The modern blast furnace and the different methods for the making of steel as at present employed are the result of a hundred years of experience, and have reached their present perfection through many modifications, which, in many instances, were accepted and introduced into practice only after much hesitation and opposition. The process of the electric reduction of iron ore must yet be regarded as in the experimental stage; in fact, no plant exists at the present time where iron ore is commercially reduced to pig by the electric process. The more remarkable, therefore, it appears, and the more gratifying it is regarding the future of electric smelting, that experiments made off-hand, so to say, in furnaces not at all designed to be used for the production of pig should give a figure of cost which would enable the experimental plant employed to compete with a blast furnace in regions where electric energy can be had for $10 per electrical h.p.-year, and where coke is quoted at $7 per ton." Haanel states that he is "credibly informed that the water power at Chats Falls can be developed at a cost to produce an electric h.p. year at the rate of $4.50. There are probably many water powers favourably situated as regards good bodies of ore in the Provinces of Ontario and Quebec, which can be developed as cheaply." The report is concluded by an account of the Ruthenburg process and by translations of papers by Harmet, Gin, and Stassano on the electrometallurgy of iron and steel, and a paper by Vattier on the Keller process of treating copper ores in the electric furnace.

Professor Hele-Shaw, F.R.S., LL.D.

THE appointment of Professor Hele-Shaw to the important position of Principal of the Transvaal Technical Institute and Organiser of Technical Education in the Transvaal involves his resignation of the Chair of Engineering in the University of Liverpool, a position which he has held for close upon twenty years.

Professor Henry Selby Hele Shaw is by birth an East Anglian. He was born at Billericay, Essex, in 1854, and received his early education in Devonshire. In 1871, at the age of sixteen, he was articled to the profession of engineering at the Mardyke Engineering Works, Bristol, and he remained there four years. Subsequently he was engaged for some months at the works of Messrs. G. K. Stothert and Co., and he obtained the Senior Whitworth Scholarship of his year. This enabled him to resume his studies at University College, Bristol, where he twice secured the Senior General Scholarship. He was also awarded the Miller Scholarship of the Institution of Civil Engineers for his paper on "Small Motive Power." In all, he won in competitive examinations scholarships and prizes to the value of £760. Upon the conclusion of his college course in 1879, Mr. Hele-Shaw was offered and accepted the appointment of Lecturer in Mathematics and Engineering in his own college. This post he held until 1881, when he was promoted to the Chair of Engineering, which he continued to hold until, in 1885, he was appointed first Professor of Engineering in University College, Liverpool. Within two years of its provisional creation, the department of engineering was equipped upon a scale unsurpassed at any college or university in the United Kingdom, and placed upon an educational basis as permanent as that secured to any other of the arts and sciences.

Under the administration of Professor Hele-Shaw the growth of the Engineering School has been most rapid, having steadily risen from three students at the commencement to 130 in 1903.

Professor Hele-Shaw has found time to contribute a large number of professional and scientific papers on various subjects to learned societies, and he has been awarded the Watt Gold Medal and Telford Premium of the Institution of Civil Engineers for his paper on "Mechanical Integrators," and for his contributions to the Institution of Naval Architects he was awarded their gold medal.

Last year upon the invitation of the Colonial Secretary, Professor Hele-Shaw went out to the Transvaal as organiser of technical education. On arrival he accepted the position of senior and responsible professor of the new technical institution, which he duly opened, with, besides himself, five assistant professors in engineering, geology, mining, chemistry, physics and electo-technics. Forty-three students, both Dutch and English, who were taking the examinations of the Cape University in mining, presented themselves. In addition, evening classes were opened at Pretoria, Johannesburg, and other places on the Rand, and were attended by several hundred students.

The work of the institute began in two temporary buildings, but these were soon found inconvenient. In place, however, of erecting permanent premises, eight temporary buildings were designed as lecture halls and laboratories. The buildings, which it is hoped will shortly become the Transvaal University, are situated in Plein Square, Johannesburg, where are also in course of erection a library, museum, art gallery, and other public halls, the whole forming a group which, when completed, will be one of the finest in the world,

In addition, Mr. Beit, of Wernher, Beit and Co., has given for educational purposes an estate of several thousand acres, beautifully situated between Johannesburg and Pretoria, and estimated to be worth £80,000. In view of developments the council of the institute, at first a small body, has been enlarged by the addition of members representing the chief mining houses, the municipal councils of Johannesburg, Pretoria, and other towns, and the Government.

Professor Hele-Shaw has been appointed first Principal, with the responsibility of the work of technical instruction. He will advise the technical council as to the foundation of the future university and on technical education generally. When last in South Africa he undertook enquiries at the requests of the Orange River Colony and Natal Governments, and his reports have led to the appointments of commissions.

CATALOGUES AND TRADE PUBLICATIONS.

TRANSPORT.

The Rectory Engineering Co., Ltd., Fulwell Road, Sunderland.—Booklet fully describing the design and details of construction of their steam motor wagons for economical transport on roads.

WOODWORKING MACHINERY.

Stone, J. B., & Co. 185, *Finsbury Pavement, E.C.*—Pamphlet 3 of the Linderman Manufacturing Co., describing Linderman's dovetail glue jointer machine. Style, endless bed.

ENGINEERING AND CONSTRUCTIONAL IRONWORK.

Phœnix Foundry Co., Ltd., Derby.—An interesting and well-illustrated catalogue of cast-iron work, for which this firm is famous, comprising bridge and other constructional castings, also of Hobson's patent flooring, pipes, girders, roofs, etc.

PNEUMATIC TOOLS.

Marshall, Horace P., & Co., 6-7, *Cross Fountaine Street, Leeds.*—Catalogue of labour-saving profit-producing machines for the foundry, with special reference to pneumatic hammers, moulding machines, sand rammers, screen shakers, etc.

Turnbull, Jun., J., & Sons, 190, *West George Street. Glasgow.*— Circular of "Cleveland" pneumatic tools, and Bowe's patent hose couplings for air, steam and water. This coupling arrangement would seem very simple, the screwing-up process incident to the older style coupling being eliminated, with the result that much time and expense is saved.

Brotherhood, Peter, Belvedere Road, S.E.—Catalogue devoted to the illustration and description of air compressors designed specially to meet the growing requirements of users of pneumatic tools and other machinery and appliances worked by compressed air. All parts of the machines are standardised so that replacements can be made from stock.

HYDRAULIC MACHINERY.

L. P. Morris Co., Port Richmond Iron Works. Philadelphia U.S.A.—Bulletin No. 1, describing and illustrating with photos and sectional views recent installations of turbine and heavy centrifugal pumping machinery.

ELECTRICAL ENGINEERING.

Mather & Platt, Ltd., Manchester—2nd edition of their pamphlet dealing with polyphase generators These are of the revolving Field type, with stationary armature arranged for direct coupling.

STEAM SPECIALITIES.

British Steam Specialities, Ltd., Leicester.—Pocket diary for 1905, containing an abridgement from the larger catalogue.

John Thom, Patricroft.—Catalogue of steam valves, relief valves, expansion joints, cocks, etc.

SHIP DECK MACHINERY.

Clarke, Chapman & Co., Ltd., Newcastle-on-Tyne.—Pocket diary for 1905, with an abridged list of specialities.

STEAM ENGINES.

Matthews & Yates, Ltd., Swinton.—Pamphlet descriptive of a new high-speed enclosed type forced lubrication engine, the special feature of which is that it has been designed for fan and dynamo driving.

WATER APPLIANCES AND BORING PLANTS.

John Thom Patricroft.—Catalogue of sluice valves, headstocks, check and retaining valves, filters, etc.; also one of water-raising appliances, such as borehole pumps, windmills, well pumps, and of boring plant.

CALENDERS, ETC.

W. Summerscales & Sons, Ltd., Keighley.—A neat calendar for hanging or standing on the desk, showing a month at a glance.

W. T. Glover & Co., Ltd Trafford Park, Manchester.—A very fine calendar of great interest and use to both electrical and mechanical engineers.

Thos. Robinson & Sons, Ltd., Rochdale.—Clear block calendar showing six days per sheet.

E. Green & Sons, Ltd., Manchester.—Useful letterweight for editorial table.

BOILER CLEANSER.

Power Speciality Co., Detroit, Mich., U.S.A.—New patented invention for cleaning steam boilers. Diamond steam flue blower is installed in rear wall of boiler, and blows the soot, with the natural draught of the boiler, to the front and out through the chimney. Time of operation, about 5 minutes.

GREASE SOLVENT.

Beanland, Perkin & Co., Leeds—"Gresolvent," for the quick removal of machine grease, ink, etc., from the hands.

MACHINE TOOLS.

G. F. Smith, Ltd., Halifax.—A thoroughly up-to-date illustrated and descriptive catalogue of machine tools, etc. Full specifications and prices are given of the principal machines, which appear to possess all the leading and latest improvements.

MANUFACTURERS' SUPPLEMENT.

Water Purifier and Grease Eliminator.

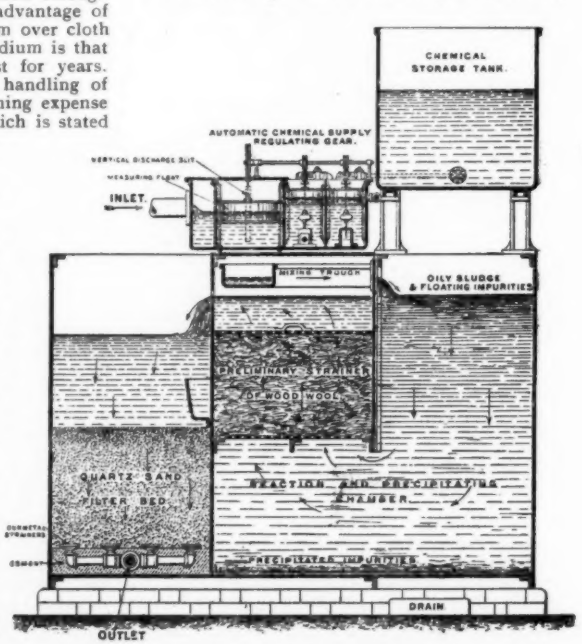
THE difficulty of removing all traces of oil from greasy condensation water is a fact well known to engineers; indeed, many of them are of the opinion that it is altogether impossible. It is when the separation is attempted by mechanical filtration that this difficulty is made manifest, as the simplest experiment will show that the very finest filtering medium is of little or no use to remove the emulsified oil.

In the apparatus illustrated in the accompanying figure the oil is removed by chemically treating the water so as to produce coagulation of the oily particles, which are subsequently removed by filtration through a quartz sand filter bed. The advantage of quartz sand as a filtering medium over cloth or any other fibrous filtering medium is that it is indestructible and will last for years. A further advantage is that no handling of it is required, and the only running expense is the cost of the coagulant, which is stated never to exceed a penny per 5,000 gallons.

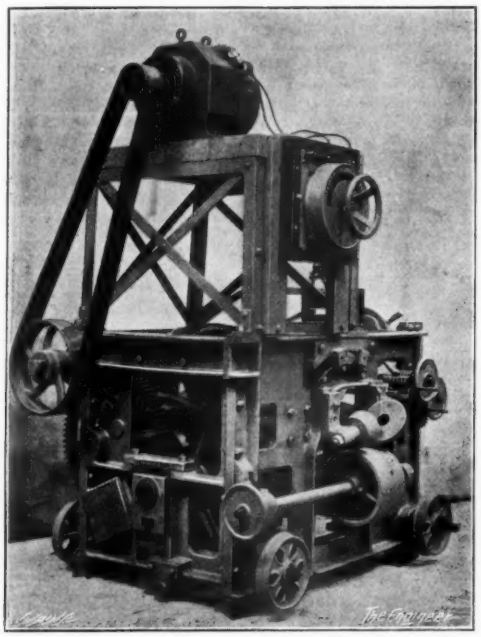
The greasy condensation water, after passing through a perforated baffle plate to free it from undue agitation, enters the measuring float chamber of the automatic chemical supply gear, and overflows through the vertical discharge slit or weir, into the mixing trough below, where it commingles with the coagulent discharged by the taper valve in the chamber adjacent to the chemical storage tank, to which it is connected by a ball valve for maintaining a constant head of reagent above the valve seat. The other valve chamber may be connected to the make-up water supply, and adjusted to add from 5 per cent. to 10 per cent. make-up at this point.

The bulk of the grease separates out on the surface of the water in the reaction and precipitating chamber in the form of a thick sludge, which can be overflowed to waste when necessary. The sedimentary matter falls to the bottom, and is flushed to the drain periodically. The water is partially clarified before passing into the filter by upward straining through wood wool shavings, contained in the preliminary strainer.

The filtering medium employed is a specially mined quartz silver sand (almost pure silica) resting upon a bed of fine pea gravel. The action of the coagulent is to form an exceedingly fine, harmless, gelatinous precipitate, which seals up the interstices between the sand grains and forms an impervious barrier to the oily globules. The pure water is drawn off uniformly from the under side of the bed through a large number of gun metal strainers, screwed into



THE PATERSON WATER PURIFIER AND GREASE REMOVER.



MESSRS. DAVIS AND PRIMROSE: PATENT BEVELLING MACHINE.

the manifold pipe system leading to the pure water outlet duct. These strainers are fitted with finely-perforated renewable phosphor bronze screens. An automatic outlet controller, by throttling the outlet discharge, prevents the possibility of the filter being drained empty when running on light load.

To wash the filter, the current of water is reversed through the bed and the impurities flushed over the waste gutter to the drain. This cleansing is assisted by the agitation, aeration, and sterilization obtained from forcing air through the bed by means of the air injector. Attention is required about ten minutes daily for re-charging the chemical storage tank and flushing out the filter. In electric lighting stations, during the summer, when the load is light, the purifier may only require attention once a week.

The makers of the apparatus, Messrs. The Paterson Engineering Co., Ltd., of Glasgow, guarantee that it will absolutely remove all trace of oil both in the mechanically suspended and emulsified forms, and to effect this, the maximum drop of temperature between the inlet and outlet does not exceed 10 deg. F. We may mention that the makers specialize in all forms of apparatus for obtaining pure soft water for steam raising and industrial purposes, and have supplied a large number of Paterson filters, softeners, exhaust heaters, and grease eliminators for electric lighting, tramway, and other power stations.

Patent Bevelling Machine.

SHIPS are now, as a rule, built of steel plates, with ribs or frames made up of steel angle bars, although other sections are occasionally used. The machine used for altering the relative angles of the respective flanges of the bars to suit the outline of the shell of the ship is shown in the illustration on this page. The bars, as rolled at the steel works, have the flanges at right angles, that is, at 90 deg.; but it is only at the mid-length of the ship that such bars would suit the requirements of the case, viz., to have one flange lying close to the shell-plates, while the other is normal or at 90 deg. to the line of the keel. Further forward or aft, owing to the tapering form of the ship, it is obvious that, if the one flange is maintained at right angles to the line of the keel, the other must be at a different angle than 90 deg., in order to lie close to the ship's plates or shell. These patent bevelling machines are employed to give the necessary and bevelling angles to the angle bars composing the ribs or frames. By arranging that the flange lying next to the shell plates always is placed towards the mid-length of the ship, the alteration on the angle is to make it obtuse—that is, greater than 90 deg.—and is termed "open bevelling." There are, however, a few parts of the ship that require the reverse operation to be performed, viz., the angle of flanges to be made less than 90 deg. or "shut bevelled." The bars to be bevelled are heated in a furnace 40 to 60 ft. long. The machine is moved along rails laid in front of this furnace. When a bar is sufficiently heated, men draw it out of the furnace by means of long hooked rods until the rollers of the machine catch hold of it; then the bar is passed through the machine at a speed of about 50 ft. per minute, being bevelled to the correct angle in passing. Having passed through the machine, the bar falls on to a floor composed of cast-iron

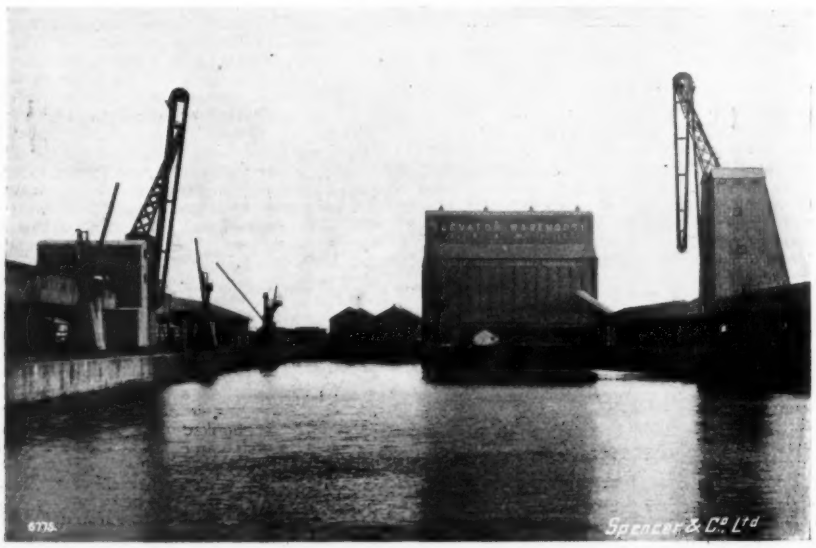
plates with numerous holes in them for bolts, spikes, or dogs. Sufficient heat remains in the bar to permit of its being bent into the curve of the ship's section.

There are indices on the machines to guide the operators in giving the correct amount of bevel. Thus, there is an index indicating the length of bar that has passed the bevelling point, and another showing what angle is being given at the particular spot. It is the duty of one of the operators to see that the spots or points on the indices agree with what has been ascertained from measuring the full-sized section of the ship in the moulding loft. The work being done between rollers, the bars are smoothly and accurately bevelled without injuring the material, also so expeditiously that, as pointed out before, they can be bent into the curve without reheating. When no machine is used, but the work done by hand, the bars are pulled out of the furnace on to the cast-iron floor, one flange held down by "dogs," and the other flange bevelled over by "weases," twisted and hammered to get the proper bevel. The work consumes much time, and, when completed, there remains so little heat in the bar thus imperfectly bevelled that it has to be returned to the furnace for reheating ere it can be bent to the curve. Messrs. Davis and Primrose, of Leith, who are the sole makers and patentees of the patent bevelling machines, have supplied them to most of the important shipyards in the world. The machines are either driven by a steam engine or by electric motor attached, the latter method now being mostly used, as all shipyards of any size now have electric current at command.

The smaller machine is termed No. 1, and takes angle sections up to 7 in. × 5 in. × 9-16ths in. The larger machine, or No. 2, takes angles up to 9 in. × 9 in. × 1 in., or bulb angles up to 10½ in. broad, 5 in. deep, and ¾ in. thick. Both machines are arranged for operating on channel sections.

Grain and Seed Handling Machinery.

THE unloading of a vessel carrying a cargo of grain by ordinary manual labour was, in times past, an expensive and lengthy operation, now, fortunately, no longer necessary, owing to the introduction of special appliances for the mechanical handling of the produce, both as regards unloading the vessel and delivering to and from the granary. Many of the large docks and grain warehouses have within the last few years been equipped with the machinery available for these duties, a large number of which installations have been carried out by Messrs.



MESSRS. SPENCER AND CO. ELEVATING PLANT AT THE EDINBURGH DOCK, LEITH.

Spencer & Co., Ltd., of Melksham, Wilts., who claim to be the pioneer firm of this country in this line of business, and who advertise extensively in these pages, giving every month illustrations of special installations or features of their manufactures. The accompanying illustration shows a very complete installation carried out by the above-named firm recently at the Edinburgh Dock, Leith. This installation consists of a fixed elevator and other machinery connected therewith capable of taking grain from the largest vessels coming into this dock, at the rate of 400 tons per hour. There is also a fixed elevator for taking from barges at the rate of 120 tons per hour, and a travelling ship elevator with a capacity of 75 tons per hour, as well as all the necessary intermediate conveyors, etc., for transferring the total quantity of about 600 tons of grain per hour into the warehouse.

This class of apparatus calls for special experience and specially-constructed tools for its production, and is a specialty for which it is useless to go to the ordinary mechanical engineer. The points necessary for satisfactory working can only be understood by close study of the requirements, and this Messrs. Spencer & Co. always do. It is quite possible for them to supply a complete grain intake or delivery plant, having a capacity of from 20 tons up to 1,000 tons per hour, for all of which they have standard designs and patterns. They also have special methods of storing grain in various ways suitable for every case likely to arise.

Electric Motors.

THE new catalogue of continuous current motors received from Messrs. Crompton and Co., Ltd., of Chelmsford, contains a great deal of information concerning the machines now being manufactured by them. These motors have been fully standardized, and are being manufactured in very large quantities, to do which economically Messrs. Crompton have to adhere rigidly to their standard designs. Driving conditions, however, differ so largely that they often introduce considerable modifications in the mechanical parts. In the past, British makers have been in the habit of carrying out these alterations either free or at a comparatively small extra charge. They have, however, only been able to do this either by manufacturing the machine in small quantities, or else by charging such a price for the standard machines that it will cover, to a certain extent, the cost of these alterations. Foreign competitors, however, have adhered more rigidly to their standard designs, and refused definitely to make any alterations to their standard patterns.

Messrs. Crompton have endeavoured in this list to take a middle course, and have reduced the prices of standard motors to the very lowest figure, not considering it fair that customers who accept standard designs should bear any portion of the charges entailed by the special requirements of other customers. At the same time, if special modifications of standard designs are required, Messrs. Crompton charge the full cost of the same.

People possibly do not appreciate the cost entailed by some of these modifications. For example, it appears, at first sight, quite an easy and inexpensive matter to lengthen the shaft of a motor beyond the normal; but where machines are manufactured in large quantities, an alteration of this description involves building a special armature by itself, and the cost of making a single part is, of course, enormously greater than the cost of making the same part in bulk.

We have dealt with this matter at some length, as it explains the system on which the new catalogue has been arranged. A plain motor has been taken as a basis, and quotations are given separately for each ordinary variety of driving gear, from the ordinary belt pulley to a geared motor. There is also given the over-all dimensions, net and gross weight, and shipping measurements, particulars of standard pulleys, flywheels, couplings, foundations, bolts, etc.

In the geared motors three different speed ratios for each machine have been standardized, and the question of "variable speed" and "totally enclosed," and "reversible crane" motors have been dealt with.

Starters, for the purpose of the list, are divided into three different types, each type representing a different rating in the resistance, viz., light load starters, half-load starters, and full load starters. These starters are listed with no-volt and over-load releases, and the various extras required for each type are quoted for separately.

Hydraulic Plant.

MESSRS. RICE & CO., LTD., Leeds, whose works are situated in Elland Road, Leeds, occupy a high standing as manufacturers of hydraulic tools, suitable for boiler-makers, bridge builders, shipyards, constructional engineers, and many other trades where hydraulic power has proved its adaptability and usefulness. Messrs. Rice are constantly manufacturing belt and motor-driven pumps, pumping engines, accumulators, fixed and portable riveters, presses for all classes of work, cranes, punches, and shears, and are at present busy with a large contract for a foreign Government. They also have in progress large and powerful presses for some of the most important boiler-makers in this country.

The workshops are large and lofty, and are equipped with powerful overhead cranes, and some of the latest type tools using the high speed steels. Altogether, their workshops are admirably adapted for producing their speciality of hydraulic tools.

Electric Driving in Textile Mills.

MESSRS. MATHER & PLATT, LTD., of Salford Iron Works, Manchester, have recently settled an important contract for the plant required for the electric driving of two cotton mills in Spain, which will be one of the largest and most complete installations of the kind. The well-known spinning and weaving mills, with adjoining dye and hosiery works, at Malaga, in Andalusia, belong to the Marquess of Larios, who was a pioneer in starting Spanish manufactures, and are the largest in the country, employing about 5,000 hands. Arrangements have lately been made by the Marquess for obtaining a supply of electric power from the Chorro Power Company, which has established a generating station in the celebrated Chorro Gorge, some 50 miles north of Malaga. The power is transmitted by three-phase current, at a pressure of 25,000 volts to a sub-station in Malaga, where the pressure is reduced to 2,500 volts, part of the energy being supplied to the Malaga Electric Lighting Station.

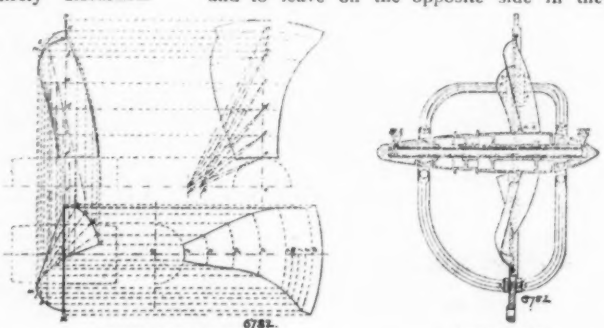
The contract which has been secured by Messrs. Mather & Platt, Ltd., includes the underground cables from the Malaga sub-station to the two mills "La Aurora" and "La Industria," which are at a distance of about half a mile. A secondary receiving station is to be placed at each mill, containing three-phase transformers for reducing the pressure from 2,500 to 400 volts for supplying the three-phase motors, which will be employed universally throughout the mills, the steam plant being entirely discarded. There will be seventy-two motors, varying in power from 3 h.p. to 150 h.p., and aggregating 2,500 h.p. The Larios Company anticipate that by the use of electricity in place of steam they will save considerably more than 20 per cent. of the yearly cost of power.

There was a very keen competition for the contract by the leading Austrian, German, and Swiss firms, and it is highly satisfactory to find that on neutral territory a British firm can secure such a contract in open competition, especially for polyphase plant, to which it has been generally assumed that British makers have devoted less attention than their Continental competitors.

Fans.

THE problem of designing and constructing a thoroughly efficient machine for the moving of air in volume is not so simple as might at first appear to be the case. Certainly of those who have attained a high degree of efficiency in this form of apparatus Messrs. Hattersley, Pickard & Co., of Leeds, occupy a prominent place, the screw fan of their manufacture being designed throughout on correct scientific principles and carefully carried out in construction.

The blades being the most important feature of the fan, it will be seen from the accompanying illustration that those of this fan are designed on the principle of the screw with longitudinally increasing pitch, each blade being a portion of one thread of the screw, having six parallel threads of great depth wound round its centre. In consequence of this helical formation, the angle of the blade varies at every point from root to tip in proportion to the diameter and speed of revolution. This gives uniformity of velocity over the whole effective area of the fan, and maintains an even pressure of air, enabling it to overcome a large amount of resistance. Owing to the friction of the air on the fan blades, centrifugal action is set up, causing the air to pass through in a diagonal direction, and to come out on the discharge side farther from the centre than it entered. In order to meet and take advantage of this action, the blades of the Hattersley-Pickard Patent Fan are set back towards the intake, thereby allowing the air to cross them at right angles and to leave on the opposite side in the



GEOMETRY OF THE BLADES — SECTION OF FAN

HATTERSLEY, PICKARD AND CO.: DETAILS OF FAN.

shortest time, thus reducing skin friction to a minimum. These methods of construction render the fan particularly well adapted for blowing or exhausting.

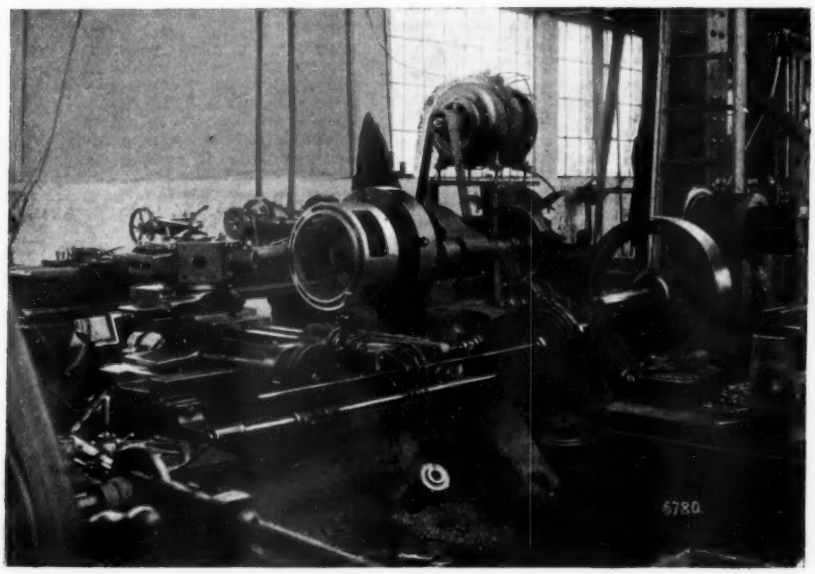
The blades are bound together by a wrought-iron ring, to which they are securely riveted. By reason of their shape and construction, they do not require any ribs to support them, which ribs would cause additional friction to the air passing through the fan.

Owing to the slow speed at which the centre of a fan revolves, compared with the circumference, it is practically of no use for moving air; in fact, it happens frequently, when working, that the air passing through the outer portions of the fan has a tendency to turn round and go back through the slow-moving centre. To counteract this action, the centre of the Hattersley-Pickard fan is filled up by a large boss of smooth surface and light construction, which runs quietly and prevents the escape of the air in any but a forward direction. Its exterior is so shaped, in conjunction with the driving pulley and bearings, as to be in the form of a cigar or torpedo, the surface throughout being practically continuous, without unnecessary gaps or irregularities, thereby allowing the air free access to the blades and reducing eddies and back currents to a minimum.

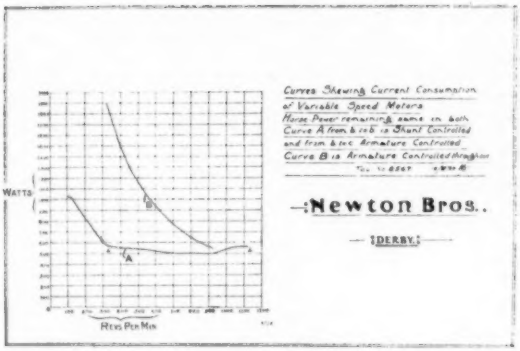
It may be added that the bearings are self-adjusting and dust-proof, and the whole construction is such as to show that the makers' object to produce a highly efficient apparatus, both as regards power consumed and volume dealt with, has been fully achieved.

Automatic Speed Regulation for Machine Tools.

MESSRS. NEWTON BROS., of Derby, have recently introduced an improved arrangement for the automatic speed regulation of machine tools, for which the following advantages are claimed:—(1) Saving in power. (2) Automatic speed regulation, obviating the use of cone pulleys. (3) Any degree of speed variation can be obtained. (4) The cutting speed at the tool point is kept constant automatically. (5) The cost of equipment is less than that of the ordinary motor-driven tool with series control. (6) The operation of the tool equipped with this apparatus is simple, and much saving of time is effected. The accompanying diagram shows the saving of power claimed by this method of driving over that of the series controlled motor, and the photograph shows a Lang Lathe so equipped. This machine was made for ordinary belt driving, and later was fitted with



MESSRS. NEWTON BROS.: AUTOMATIC SPEED REGULATING ATTACHMENT


Curves Showing Current Consumption of Variable Speed Motors
Horse Power remaining same in both
Curve A from b to b is Shunt Controlled
and from b to c Armature Controlled
Curve B is Armature Controlled throughout
WATTS
Revs. Per Min.
Newton Bros.
DERBY.

Newton's Patent. The driving apparatus consists of variable speed, shunt controlled motor, with shunt resistance, the latter being operated by a suitable arrangement from the saddle of a lathe or a convenient part of any machine tool. The operator has only to bring the tool to the position required for the particular article to be machined, and in doing so the speed of the motor is automatically adjusted to give the correct cutting speed for the diameter required. For instance, in turning a cone pulley, if the steps vary only, say, 1 in. in diameter, in moving the tool from step to step the cutting speed remains automatically constant throughout. Also in finishing work none of those marks are visible which obtain when the speed is varied in a cone-driven tool when the belt is moved from one step to another.

This adjustment is not effected at the expense of energy wasted through the resistance of a heavy controller, but by controlling the small current in the shunt field of the motor, which reduces its efficiency only very slightly. The apparatus can be suitably applied to any kind of machine tool in which automatic variation in speed is an advantage.

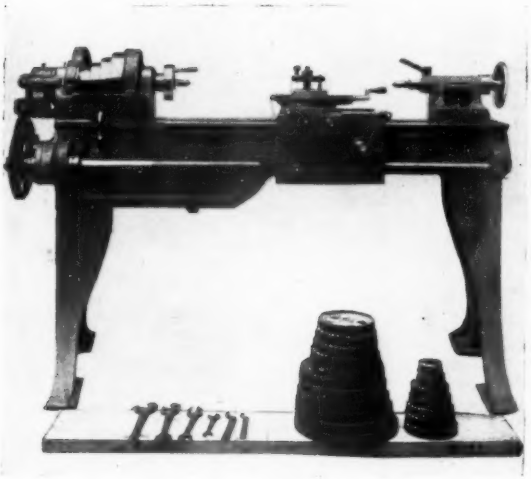
Hack Saw Blades.

THE modern form of this small but indispensable workshop sundry, at least as far as the American type is concerned, has of late years very largely displaced the original pattern, which in making was left soft enough to enable the teeth to be refiled and reset when worn. It lacked in consequence the keenness of cut and durability of edge which is characteristic of the new form, and the greater cheapness of the American product more than compensated the loss involved in throwing away a blade when its teeth were dulled. We are glad to notice, however, from an announcement appearing in our advertising columns, that the manufacture of this article in the modern and more efficient pattern has been taken up by the Lancashire firm of Chas. Baynes, of Blackburn, who, by laying down a special plant and confining themselves to the manufacture of this article alone, are now able to compete on equal terms with the foreign makers and thus restore this branch of industry to English trade.

A Surfacing and Screw-cutting Lathe.

THE accompanying illustration is that of a 5 in. centre, self-acting, sliding, surfacing, and screw-cutting lathe recently made by the Britannia Engineering Company, Ltd., of Colchester, to the order of the Government. It is arranged for working in either single or double gear, and is specially adapted for using high-speed cutting steel, the machine being capable of taking heavy roughing cuts while running on single gear. The principal dimensions are as follows:—Height of centre—5 in.; bed—5 ft. long, 9 in. wide, 7 in. deep; cone pulley—four speeds, 1½ in. wide, diameters 8¼ in., 6¾ in., 5¼ in. and 3¾ in.; leading screw—1½ in. diameter, ⅛ in. pitch; back shaft—1⅛ in. diameter; approximate weight, 15 cwt. The bed is of strong box section, and has a large bearing surface. A filling piece is fitted to the gap in such a way as not to spring the bed, and it can be easily removed and replaced in position in perfect alignment with the bed. The fast head-stock has a best hardened steel spindle running in accurately ground steel conical bearings having a large surface. The tail stock is of substantial construction, and is fitted with a cross traverse for taper turning. The saddle is of specially strong construction, and is arranged with a quick hand traverse along the bed by rack and pinion. The slide rest, which is provided with independent and longitudinal traverse, is fitted with a full swivel and indexed for conical turning.

A back shaft having both variable and adjustable motion is fitted along the entire length of the bed for giving the self-acting sliding motion to the saddle and a surfacing motion to the slide rest. All gearing, including the change wheels, is machine cut out of the solid. The wheels operating the leading screw in no way interfere with the back shaft motion. The screw motion is reversible, so that right and left hand threads can be cut without changing the



BRITANNIA ENGINEERING CO., LTD.: NEW LATHE.

wheels. The lever operating the change gear is readily accessible, and three changes of feed are provided. All exposed gearing is completely enclosed by guards to prevent the possibility of accidents and to comply with the requirements of the Factory Act.

Tar Macadam Mixers.

TAR MACADAM is now being so very largely specified for and used in the construction of roads, streets, and footpaths that a mixing machine has now become essential to town councils, road contractors, and others concerned with the production or use of the material. The machine illustrated herewith has been placed on the market by Messrs. Goodwin, Barsby & Co., of Leicester, and is of simple construction. It consists of a steel cylinder which revolves on bearings mounted on a shaft driven by a handle or pulley and gearing. The cylinder has an aperture at each end, one for inlet and the other for outlet. The slag or limestone is dried and then fed by means of a hopper into the cylinder, into which is also fed from a cistern near the hopper the properly prepared tar. The two materials are thoroughly mixed in the cylinder, the process being assisted by metal blades, shaped and placed in a spiral position. Slow fires in the furnaces keep the tar sufficiently fluid to properly impregnate the stone, the smaller machines having two furnaces each and the larger three. The whole is self-contained in steel casing on an iron frame, and works with very little consumption of power; in fact, small quantities can be mixed by hand power. The cost of mixing tar macadam with this machine, we are informed, works out at considerably less than 6d. per ton even when taking a minimum of 40 tons per day. A contractor using one of these machines recently began and finished a contract comprising 1,973 sq. yds. of tar macadam laid 6 in. thick in three separate layers, in only 10 days, without overtime, this including excavating the site, rolling the macadam, and clearing away. The gauge of the material makes little or no difference to the quantity of work done. It may be pointed out that this machine is a tar macadam mixer only, and is not a stone dryer or a tar boiler. We understand that machines and complete plants to combine the two or three processes are now being designed by Messrs. Goodwin, Barsby & Co. to suit various sites in which they may be intended to work.

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MESSRS. GOODWIN, BARSBY AND CO.: TAR MACADAM MIXER.

Raw Hide Pinions.

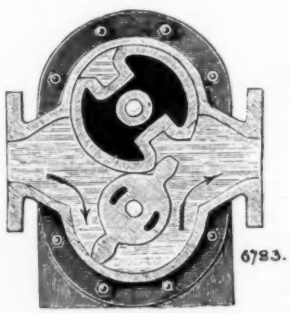
THE rapid increase in the demand for high speed electrical machinery has called for the introduction of noiseless running gears. A motor, or, in fact, any machine fitted with steel driving gear, working at a high rate of revolution, becomes intolerable by reason of noise. The problem of producing a gear which would fulfil all required conditions as to durability and speed and yet be noiseless in action was one which a short time ago the firm of Messrs. Geo. Angus & Co., Ltd., of Newcastle-on-Tyne, set itself to solve. A suggestion was found, as a result of a visit to America, in which country raw hide, suitably treated, was being utilized in the manufacture of gears. There are several different makes of raw hide gears on the market, but we believe that the firm responsible for their production was the New Process Raw Hide Co., of Syracuse, U.S.A., for whom Messrs. Angus & Co., Ltd., became sole agents for the United Kingdom, and are now, in accordance with an arrangement made with the inventors, manufacturing raw hide gears at their Newcastle works. The hides used are prepared by a special and secret process, and when cured and thoroughly dried, are transferred to the machine shop. It may be mentioned that only the best quality ox hides are used. In the machine shop they are cut into discs and cemented together into pinion blanks by hydraulic pressure. The blanks are then flanged, riveted, turned to size, bored, and the teeth cut in them by automatic gear cutters in the same way as in metal gear wheels, the material taking almost as fine a finish as steel. The new process of curing eliminates from the hide all the superfluous matter and leaves only the actual animal fibre, whereby the original strength of the hide is greatly enhanced and its durability increased. In addition to being practically noiseless, raw hide gears will not only wear as long as those made of other material, but will prolong the life of the wheels or pinions with which they mesh. In a pair of gear wheels only one need be of raw hide, the other being of metal, and in a train of gears metal and raw hide should alternate. Messrs. Angus & Co. are now making iron and steel standard gear wheels to work with their raw hide gears. In action, vibration is reduced to the extent that the life of the machine is considerably prolonged, a fact which is of special importance in the case of the electric motor, the armature of which will last much longer when fitted with a raw hide pinion. These gears have for some time past been in extensive demand for all sorts of high speed or high geared machinery in the U.S.A., and we understand that already the extensive plant which Messrs. Angus have laid down for producing them is kept employed at its fullest capacity.

The "Drum" Pump.

A PUMP of unusual design, which combines the characteristics of both the centrifugal and direct acting piston pump types, forms the speciality of the Drum Engineering Company, Bradford. The principle of its action may be gathered from the accompanying illustration, from which it will be seen that the rotary principle has been made use of. A revolving piston sweeps out the cylinder at each revolution, the piston dipping into a revolving valve or drum, the openings in which are so arranged that the piston passes through without slip or back pressure or undue friction. When the piston moves round from the revolving valve a vacuum is formed, into which the water flows and is forced through the front face of the piston. The "Drum" pump differs, however, from the ordinary rotary pump in that the latter is more or less intermittent in its action, and breaks up the flow of liquid, whereas the former passes the water through in one continuous flow and utilizes the momentum of the moving column. Another difference between this and the ordinary rotary pump is that the latter usually has two working pistons, one of which is driven through gear wheels. The "Drum" pump, on the contrary, has only one piston, the friction set up by the gear wheels thus being eliminated. It is recommended more particularly by the makers for contractors, drainage works, docks, on board ship for pumping semi-fluids, or generally for any purpose where large volumes are to be quickly dealt with.

Refuse Destructors.

DURING the past year, steady progress has been made in the application of the latest appliances of sanitary science, notwithstanding the temporary depression which



THE "DRUM" PUMP.

has only been too manifest in some of the Colonies. In South Africa the situation is distinctly more promising, and municipal and corporate enterprise is much in evidence. It will be remembered that in 1902 Messrs. Meldrum Bros., Ltd., supplied the material for, and supervised the erection of two complete destructor installations for the Johannesburg Municipality, each having a capacity of 60 tons per day of 24 hours. The official tests were carried out by the City Engineer, and were entirely satisfactory, and decided the authorities to duplicate the Burghersdorp installation; and with a view to utilizing to the full the steam generated by the gases of combustion, electricity generating sets are being installed, superheaters of the Babcock and Wilcox type are being fitted to the boilers, and other accessories, all with a view to the more economical production of power, are now in course of erection. The whole of the material—comprising one Meldrum Patent 4-Grate Simplex Top-Feed Regenerative Destructor Furnace, one Babcock and Wilcox Boiler (having 1,966 sq. ft. heating surface), two superheaters, one Meldrum Patent Regenerator, special firebricks, etc., etc.—was shipped within 65 days from receipt of the Municipality's instructions to put the work in hand.

In connection with the electricity undertaking for the Municipality of Kalk Bay and Muizenburg, a 2-Grate Meldrum Simplex Furnace is being applied to one of the Babcock & Wilcox boilers.

With the increasing signs of business expansion in the various South African Colonies, the prospect for the coming year is distinctly hopeful.

In Australasia, so far as the Continent is concerned, the past year has not seen any contracts placed for the manufactures now under review. Several cities and townships are, however, very much alive to the needs of the times, and may be expected to move actively in the question of refuse disposal in the near future. The report by the Medical Officer of Health for the City of Sydney on the Meldrum Simplex plant erected for the Annandale and Leichardt Councils, may be expected to revive confidence, as the results which are being obtained there have demonstrated that the problem of dealing satisfactorily with the waste of Australian cities is not beyond solution.

In New Zealand, the success of the installation put down by Messrs. Meldrum Bros., Ltd., at Christchurch, has induced several municipalities to move actively, and the Auckland City Council have just instructed them to proceed with an installation to deal with 60 tons per day. Christchurch, it should be remarked, is the first combined destructor and electricity station put to work in the Colonies, and the success of the combination has exceeded all expectations.

Furnaces.

MANY are the appliances which from time to time have been introduced to economize in steam-raising, not a few of which have been very successful and are in extensive use to-day all over the world, though many have not stood the test of time and have dropped into oblivion.

Amongst the former the Meldrum furnace can assuredly claim a place. Introduced first in the year 1889, it has met with continuous and increasing appreciation, upwards of 12,000 installations having been made on all kinds of steam boilers, as well as brewers' coppers, plaster kilns, metallurgical furnaces, and the like.

No apology will, therefore, be needed for giving in this issue a few particulars of the system, as, although not by any means a novelty, it cannot fail to be of interest to many steam users, especially abroad.

Briefly, then, the principle of the system is that of forced draught, air being delivered under pressure into the closed ash-pit of the furnace and forced or driven through the fire. The forcing, however, ends there, as, after leaving the furnace, the gases and flame pass through the boiler and flues in the usual manner and at normal speed.

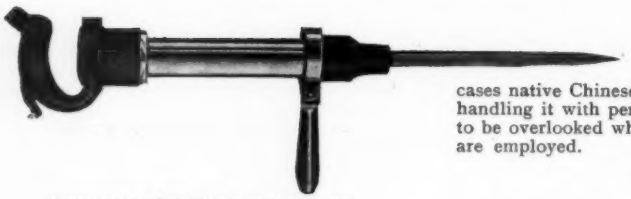
The air supply is thus well under control, and is applied exactly at the spot where it is required.

The primary air being supplied solely under the grate and driven through the fire, the excess of air can be kept to the lowest point. With forced draught, also, the furnace is worked with the dampers lowered, as far as practicable, with a view to keeping the hot gases in contact with the heating surface of the boiler as long as possible and abstracting the maximum of heat therefrom for useful work.

When the doors are opened for firing or clinkering, just sufficient draught can be left in operation to obtain a pressure in the furnace equal to the pull of chimney; consequently little, if any, cold air need be admitted, and the temperature of the furnace is maintained at the highest and most uniform degree.

A boiler worked under forced draught is able to meet varying demands for steam in the most convenient manner, as the rate of combustion can be varied at will by simply increasing or decreasing the supply of steam to the blowers and thereby augmenting or reducing the volume of air supplied to the fire.

Forced draught likewise enables the most inferior classes of fuel to be utilized with excellent results. Fine coal, coke breeze, colliery waste, and the like, which is almost useless with ordinary methods of firing—chimney draught being quite inadequate for burning it, can with this system be turned to good account as boiler fuel. In various parts



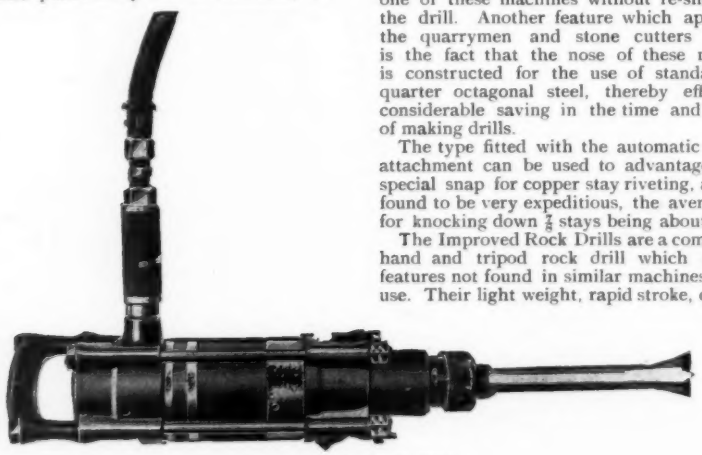
CONSOLIDATED PNEUMATIC TOOL CO., LTD.
NO. 1. HAMMER WITH ROTATING DEVICE.

of the world native coal is available, but often of relatively poor quality, which with forced draught can be utilized very successfully and effects enormous savings as compared with the cost of working on imported coal.

The forced draught is actuated by means of special steam-jet blowers, the steam used being thoroughly dried by a special arrangement for the purpose, so as to prevent condensed moisture finding its way into the ash-pit and corroding the plates.

The fire-bars used with this system are, in common with all the other fittings, designed expressly for forced draught working. They have very narrow air spaces, so as to burn fine fuel without waste through the grate; and this also ensures equal distribution of the air pressure under the bars and the prevention of blow-holes in the fire. Special means are also employed for burning smoke, in which respect the "Meldrum" is very efficient.

From the foregoing details it will be evident that the Meldrum furnace is a thoroughly efficient and economical method of boiler firing. Not the least of its advantages, more particularly in the Colonies, is that no specially skilled attention is required to work it successfully. In many cases native Chinese and Hindoo firemen are handling it with perfect success, a factor not to be overlooked where such classes of labour are employed.



NO. 2. IMPROVED ROCK DRILL.

Pneumatic Labour-Saving Machines

THE Consolidated Pneumatic Tool Co., Ltd., of Palace Chambers, Westminster, are introducing some new types of pneumatic labour-saving machines, which are illustrated in the accompanying figures. The well-known Boyer hammers, so extensively used in the leading quarries of this country for plug and feather work, are now being made in three sizes, covering all grades of plug and feather drilling, and in two types, the difference between which consists in the rotating attachment, which in one case is automatic, and in the other is operated by hand.

The light weight of these machines admits of their being easily held by hand, and they are, therefore, successfully used for either top or side line work. On one occasion 131 holes $\frac{7}{8}$ in. in diameter by $\frac{3}{4}$ in. deep, were drilled in hard granite with one of these machines in 140 min., this time including the lining, changing of drills, etc.

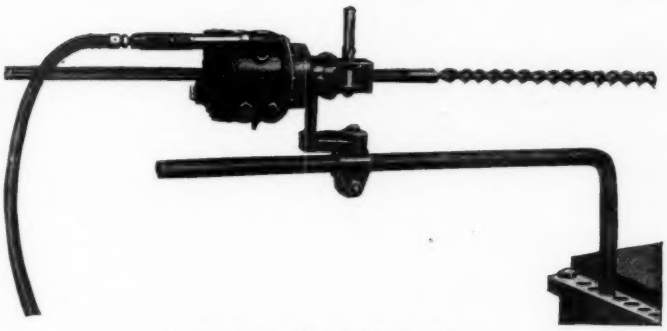
The blows delivered by these machines are light and rapid, in consequence of which the drills used do not require re-sharpening nearly so frequently as in hand drilling, and as many as 20 holes have been drilled with one of these machines without re-sharpening the drill. Another feature which appeals to the quarrymen and stone cutters strongly is the fact that the nose of these machines is constructed for the use of standard $\frac{7}{8}$ in. quarter octagonal steel, thereby effecting a considerable saving in the time and expense of making drills.

The type fitted with the automatic rotating attachment can be used to advantage with a special snap for copper stay riveting, and it is found to be very expeditious, the average time for knocking down $\frac{7}{8}$ stays being about 45 sec.

The Improved Rock Drills are a combination hand and tripod rock drill which combine features not found in similar machines now in use. Their light weight, rapid stroke, compact-

ness, and economy in air consumption, in connection with the fact that they can be used either by hand or with a tripod, as may be desirable, gives them an immense advantage over other types of rock drills.

They are fitted with an arrangement for freeing the hole from cuttings, which consists of a tube enveloping the drill bit, through which tube a blast of air is passed, completely clearing the hole of all obstructions. This arrangement is extremely valuable in cases where the class of rock being drilled does not require the use of water. Also, when so specified, they can be furnished adapted for water connection, using hollow steel.



LITTLE GIANT DRILL FITTED WITH SPLIT NUT.

The rock drills are very simple in construction, containing but 26 parts as compared to 50 and upwards of other makes, and all parts are made of hard tool steel, including the cylinder, a radical departure in the manufacture of this type of machine.

Owing to its light weight, the drill has been used by divers under water for submarine excavation work, the only alteration that is necessary being to make provision that the exhausts shall be discharged above water level.

The Little Giant Ore-Boring Machine (split nut) is one of the firm's standard pneumatic drills, fitted with a split nut attachment, arranged as shown in the illustration. When drilling, the links are locked in the closed position, and both halves of the nut are opened by one movement of the links, so that the screw bar can be at once withdrawn from the hole and a fresh bit inserted. By means of the special swivel attachment, the machine not only always finds its alignment for drilling, but the whole machine can be swung out of the line of the hole, so that the drill bit can be withdrawn without removing the drill from the wedge pit. It will drill in iron ore containing 35 per cent. to 50 per cent. of iron 1¼ in. holes at the rate of 3 ft. deep per minute, the maximum depth of holes being 6 ft. (this depth being obtained by using three drill bits).

The machine can be readily set up and operated by one man. The best results are obtained with a pressure of 80 to 100 lb., but the machine can be operated with 50 to 55 lb., the air consumption at the lower pressure being about 20 cubic ft. of free air per minute.

The No. 8 Whitelaw machine fitted with split nut averaged 40 holes 4 ft. deep 1¼ in. diameter (this depth being obtained by using three drills of varying length) in one shift, viz., from 6 a.m. to 2 p.m.

Another improved machine, known as the Whitelaw Ore Boring Drill, with automatic withdrawal and refeed, consists of a standard Whitelaw reversible drill fitted with an attachment by which, in the event of an obstruction being met, the drill will be automatically withdrawn and refed when the obstruction has been cleared.

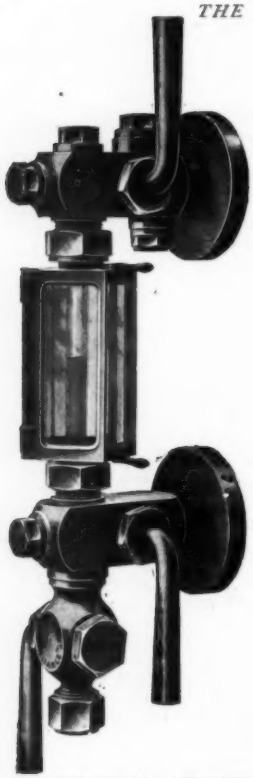
The weight of the machine complete is about 60 lb., and will drill at the rate of 3 or 4 feet per minute. The screw bar can be withdrawn from the hole in about 10 seconds by means of the operator manipulating a clutch lever which is provided at the side of the machine; the machine during all these operations running continuously in a forward motion.

Steam Specialities

A DISTINCT advance in boiler and engine fittings is to be found in the automatic water gauge manufactured by Messrs. Charles Winn and Co., of Birmingham. The special advantage of this apparatus consists in the provision of automatic valves in both steam and water arms, so arranged that, although they close instantly in the event of the glass breaking, it is impossible to tamper with them to cause a false water level to be shown.

Moreover, the valves form no obstruction to a test or cleaning rod being passed into the boiler through straight passages. They are attached to their respective inspection plugs in such a way that, although perfectly free to seat themselves on the glass breaking, they are removed with the plugs to which they are attached and therefore not liable to be lost.

The apparatus in the steam arm consists of a ball fitted freely upon a supporting spindle and attached by means of a link and angle swivel to the top inspection plug, the link and spindle being of such a length as to cause the ball to lie against one or other side of the body clear of the steam passage. In the water arm a large ball is fitted loosely upon a horizontal spindle,



MESSRS. CHAS. WINN AND CO.: AUTOMATIC WATER GAUGE.

with its seating immediately below the glass. Upon the glass breaking, the valves are automatically driven to their respective seatings, thus instantly shutting off both steam and water.

The arrangements for blowing through are such as enable this operation to be performed without interfering with the automatic valves; but to provide for blowing through the steam arm only, the water arm being shut off and the drain open, a bye-pass is arranged in the steam arm in such a way that, by reversing the handle from the working position, a clear blow through the glass is obtained.

Messrs. Winn & Co. are specialists in engine and boiler fittings, to obtain an idea of the range of which their fine section D catalogue should be obtained and consulted.

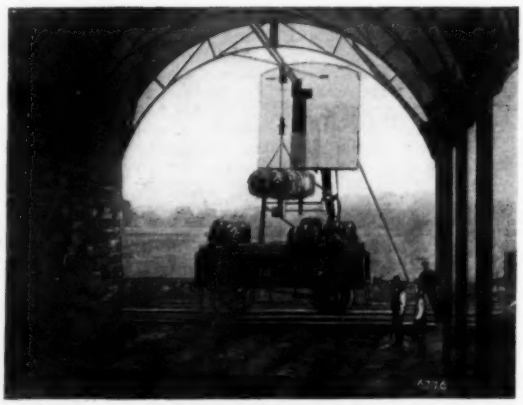
Paper Pinions.

ANOTHER material which, in addition to raw-hide, has proved its suitability for attaining noiseless drives through toothed gearing is paper pulp. Messrs. the Reid Gear Co., of Linwood, near Paisley, N.B., have devoted much time and attention to the construction of pinions made of this material, and are now putting on the market a pinion for which they claim all the qualities possessed by noiseless gearing made of other materials, with the addition that it is more economical. The company have established works installed with special plant for the production and cutting of gears in quantities expeditiously, and supply gear wheels with machine-cut teeth, in any metal, to any specification. They also cut teeth in customers' own blanks.

Hoist-Conveyors in Paper and Cotton Mills.

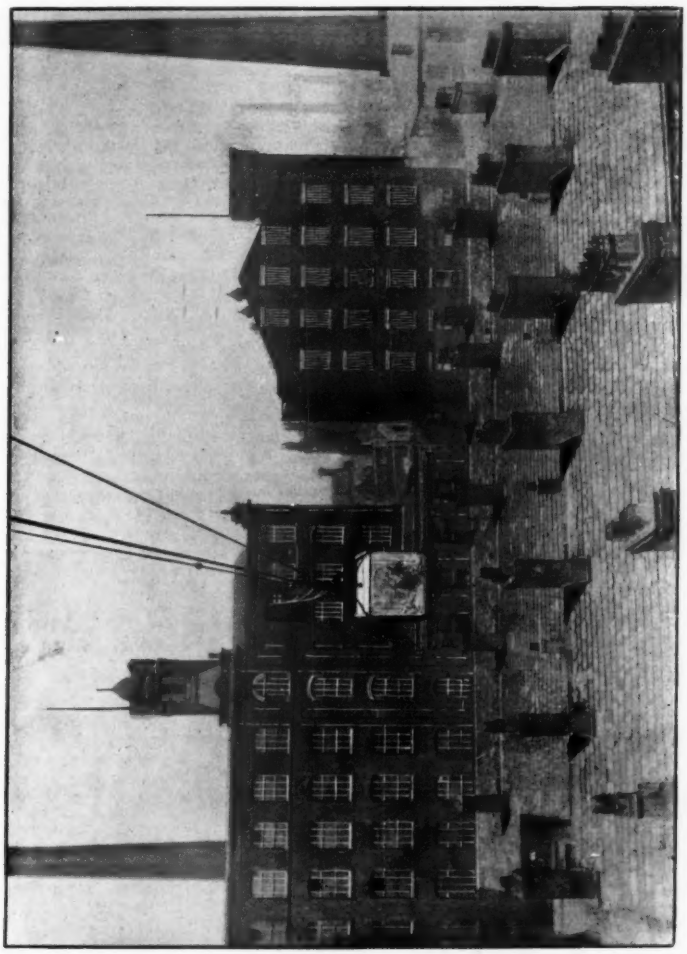
THERE are few points that merit closer consideration at the hands of the manufacturer than that of the mechanical handling of materials inside his works, and we regard it as worthy of note that such a system is being adopted in many factories where economy in the conveyance of raw or finished products is required.

The accompanying illustration is that of a hoist-conveyor, two of which were installed



J. M. HENDERSON AND CO.: HOIST-CONVEYOR AT INVERURIE PAPER MILLS.

some months ago, at the Inverurie Paper Mills of Thomas Tait & Sons, Ltd., Inverurie, N.B. The machines are of what is termed the beam type, and are used for hoisting the bales of esparto grass out of railway wagons, conveying into storage sheds and depositing the bales at any desired point along the beam. The operations of hoisting or lowering can be performed anywhere on the machine without the use of stops or trips of any kind—that is to say, the operator controls all motions independently from his platform inside the elevated housing in which the winch gear is also placed. The motive power is supplied by 100-volt continuous current motors. The rate of hoisting is 50 ft. per minute, and the travelling speed 200 ft. per minute. The length of beam in both machines is 143 ft. and the load 20 cwts. The daily capacity of each hoist-conveyor



CABLE TYPE HOIST-CONVEYOR AT THE GREENBANK COTTON SPINNING MILLS, OLDHAM.

under review is about 180 tons, which amply fulfils the requirements at these mills; but with higher speeds and dealing with similar or larger loads, the quantity handled may be increased to almost any extent.

We also give an illustration of a novel hoist-conveyor of the cable type, which has been in use at the Greenbank Cotton-Spinning Mills, Oldham, of Lees and Wrigley, Ltd., for about five years. In this case the buildings connected by the transporter are about 350 ft. apart at their nearest point, and are separated by four or five rows of inhabited houses. A comparison of the efficiency of the present system with that formerly employed may be briefly made by stating that the daily work is now done entirely under cover in three hours, whereas four or five men, under the old method, took the full ten-hour day. The winch gear is driven by a belt from one of the existing lines of shafting. The speeds are: hoisting, 135 ft. per minute; travelling, 400 ft. per minute. The load is 10 cwt.

We should add that the makers of these devices are John M. Henderson & Co., Aberdeen, whose work in other machinery of this class is well known to engineers.

Friction Clutches.

THE advantage of being able to disconnect sections of line shafting at will, and thus save power which would otherwise be wasted in driving machinery not required for use at certain periods, must be obvious to all who are concerned with the management of mills and factories. The increasing popularity of electric driving is almost entirely due to facilities of this nature, which are provided by this system; but where it is not convenient to adopt this, an economy can still be effected by the employment of friction clutches introduced at convenient points in the shafting throughout the works.

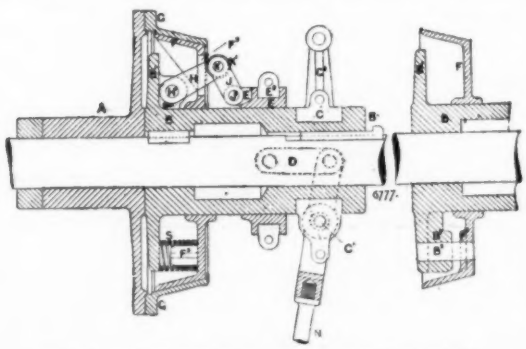
A reliable apparatus of this nature, and one which has found an extensive vogue, is the "Champion" Friction Clutch manufactured by Messrs. Durham, Churchill and Co., of Sheffield, the details of which are shown in the acompanying diagram. The construction is as follows:—

The sleeve *B* is keyed to the shaft, and runs continuously, while the pulley to be driven is mounted on boss *A*.

Sleeve *B* has at one end the flange *B* 1, and towards the other end a recess, into which is fitted the striking ring *C*, which forms a bracket providing a fulcrum *C* 1 for the operating lever *N*. *C* 2 is an "anchoring" arm provided simply to retain the operating lever *N* in any desired position. At angles of 180 deg. to each other on the flange *B* 1 are provided bosses *B* 2, into which are firmly fixed the driving pins *B* 3. These driving pins act as "carriers" to the inner cone *F*. It will be noticed that *F* is strengthened where these pins pass through it by bosses *F* 1.

The sleeve *B* has at its flanged end (at angles of 180 deg. to each other) two bosses *B* 4. To each of these are connected, by means of pins *H* 1, two links *H*, which pass through two slots *F* 2 in the inner cone *F*. Their outer ends are coupled to two other links *J* by means of pins *K*. These pins carry the rollers *K* 1. The other ends of links *J* are connected to lugs *L* 1 on muff *E* by means of pins *J* 1. The muff *E* is connected to the fork of operating lever *N* by means of a strap *E* 2 and links *D*.

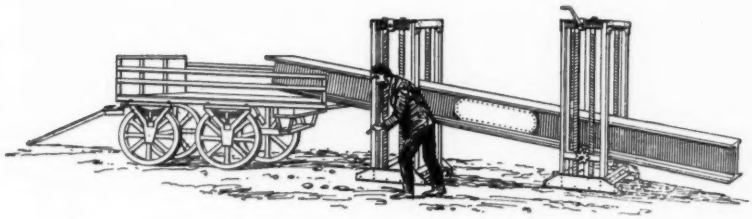
At certain positions (on the same pitch line) on *F* are provided spring pegs *F* 3, carrying springs *S*. These springs are under compression, their thrust (when driving) forcing the inner cone *F* along the sleeve *B* until its (*F*'s) frictional surface comes into contact with that of the outer cone *G*. These springs hold the cones in contact in such a way that vibration can never shake them out of gear, and they also follow up any wear which may take place in the frictional surfaces.



MESSRS. DURHAM, CHURCHILL AND CO.: SECTION OF PATENT "CHAMPION" FRICTION CLUTCH.

The operation of the clutch may now be described as follows:—

The clutch is shown *driving*, the power being transmitted from sleeve *B* (which is keyed to the shaft through the pins *B* 3 to inner cone *F*, and through *F*'s frictional surface to *G*, which is bolted to flange of *A*. *A* carries the pulley to be driven. To put the clutch out of gear, the lever *N* is moved from left to right. By means of the links *D* and the strap *E* 2, the muff *E* is moved along



MESSRS. SELIG, SONNENTHAL AND CO.: LIFTING APPARATUS.

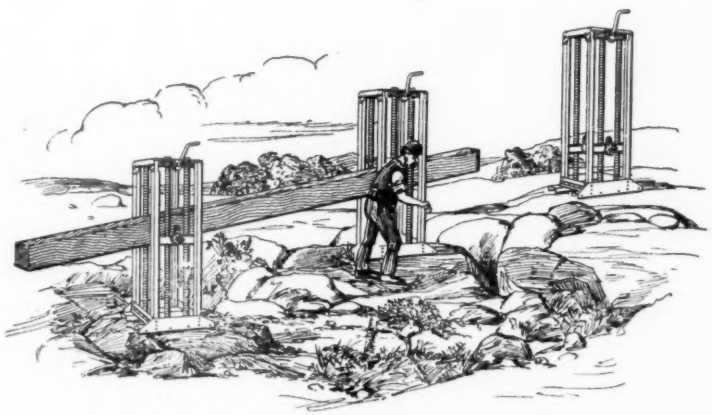
the sleeve *B* towards the cones. As the links *J* move from the oblique to the vertical they carry the ends of links *H* outwards; but as these links *H* are anchored at *H* 1, their movement is radial, and the rollers *K* 1 are therefore brought against the faces provided for them on *F*. The radial movement of links *H* being continued, the inner cone *F* is thrust back out of contact from *G*, and *G* ceases to rotate. As soon as the inner ends of links *J* pass the centres of their other ends, the springs thrust "locks" them, and the clutch remains out of gear. (In putting into gear again, the links *J* are pulled over their dead centre by means of the operating lever *N*.) When driving, there is no thrust on any collar or operating gear, and therefore no loss of power, for the cones are locked together, due to the thrust of the springs.

Every clutch carries its own operating gear. If the clutch is required as a shaft coupling, *A* would be keyed to one shaft and *B* to the other.

Lifting and Conveying Apparatus.

AN apparatus for raising, lowering, or transporting heavy loads with a minimum of labour, and which will be found invaluable for handling girders, joists, rails, pipes, etc., is the portable lifting and conveying apparatus forming one of the specialities of Messrs. Selig, Sonnenthal & Co., of 85, Queen Victoria Street, E.C. Its construction and application may be clearly made out by the aid of the accompanying illustrations:—

The lifting and lowering is effected by means of the handle on the top worm-shaft, and the load is raised and lowered with the utmost ease and safety, as the worm-gear has



MESSRS. SELIG, SONNENTHAL AND CO. PORTABLE LIFTING APPARATUS

a very great purchase. The vertical spindles are in pairs, screwed right and left hand thread, to ensure the load being raised or lowered in a uniform manner. The load can be stopped at any point and at any height desired, and there is no chance of slipping back, even under the heaviest load. The load rests on a roller, which is turned by a handle, thus giving a traversing movement either to the right or left as desired. In order to prevent the roller from slipping round when irregular-shaped work is being dealt with, thus causing the load to continue to move, a ratchet wheel and catch are provided.

To use the apparatus, the end of the girder or other material to be moved is raised so that the traversing roller can be brought under it. The roller is then raised by means of the top handle, and as soon as it is in contact with the load, the latter can be readily moved forward by turning the traversing roller. When dealing with long, thin work, it is best to employ an extra apparatus or two, so as to avoid the possibility of the work getting bent. Work can be easily transported to a considerable distance by advancing first one and then another of the appliances employed until the distance has been covered; even such difficulties as uneven ground, or holes in same, ditches, mounds, hillocks, and other obstacles being readily overcome by the proper placing and adjustment of the apparatus. For loading waggons or other vehicles this apparatus is of special utility, as one end of the object can be tilted up and thus slid on to the waggon. It can also be utilized to very great advantage in engineering shops as an auxiliary to machine tools and for other purposes; also wherever material has to be moved about, as with these appliances this can be easily done by one or two men, without regard to the shape of the work.

The "Beissel" Water Softener.

MOST steam users now recognize the necessity of treating water for boiler-feed purposes before it enters the boilers, and the old practice of using boiler compositions is being rapidly discontinued for the reason that in many cases foaming, pitting, and foul steam is thereby caused. Where naturally soft water cannot be obtained, therefore, it becomes necessary to use some suitable apparatus for purifying and softening.

The illustration in page 563 shows such a softening apparatus, known as "Beissel's" Patent, for which Messrs. Rose, Downs and Thompson, Ltd., Hull, are the sole makers for England. A number of such apparatus are working in this country, with, we have been assured, the best results.

The process of softening the water is, of course, here the same as with other apparatus, certain reagents being mixed with the hard water for the purpose of decomposing the mineral salts dissolved therein. Through the decomposition the dissolved salts are precipitated, which are removed from the water as sediment. The chief reagents used are quick-lime and alkali, the latter being usually taken in the form of carbonate of soda or hydrate of soda. This process offers in most cases no difficulty, but when and through the decomposition of the salts and the softening of the water the latter becomes turbid, and the impalpable sediments are superseded in the water, the difficulty is to remove them and clear the water. This can be done either by decantation or by filtration. The decantation of thick layers of turbid water requires, of course, a long time, and for this reason large apparatus. On the other hand, filtration can be effected with smaller apparatus, but there are other costs—for working, for filtering materials, or cleaning this material, and so on.

In the "Beissel" Apparatus the process of decantation is adopted, the turbid water being divided in very thin layers, so that no filtration at all is necessary. This means that the attendant has nothing to do but to fill in once a day the necessary quantity of reagents, and then the apparatus can be left to itself, the sediment which is precipitated by the reagents being collected at the bottom of the settling tank and removed by a "blow off" valve. It is sufficient to open this valve once a day for about one minute.

In case the attendant might not put in the right quantity of reagents, which would result in the water not clearing so well, a filter is arranged at the top of the settling tank. As this, however, is only an emergency apparatus, it seldom requires cleansing, and even this is not worth while, as the material (wood wool) would only cost about 5s. for refilling. Referring to the illustration, the settling tank is the large cylindrical part of the apparatus on the left. Iron stanchions on the top of this support a smaller cylindrical tank, which is divided into two compartments, one containing the hard water and regulating arrangements for the automatic inflow of the hard water, the other being filled with alkali—usually soda solution. The square tank contains the regulating arrangements for mixing the hard water and the solutions of soda and quick-lime in the right proportions. The solution of quick-lime is in the form of clear concentrated lime-water, which is prepared in the part of the apparatus shown between the settling tank and the steps.

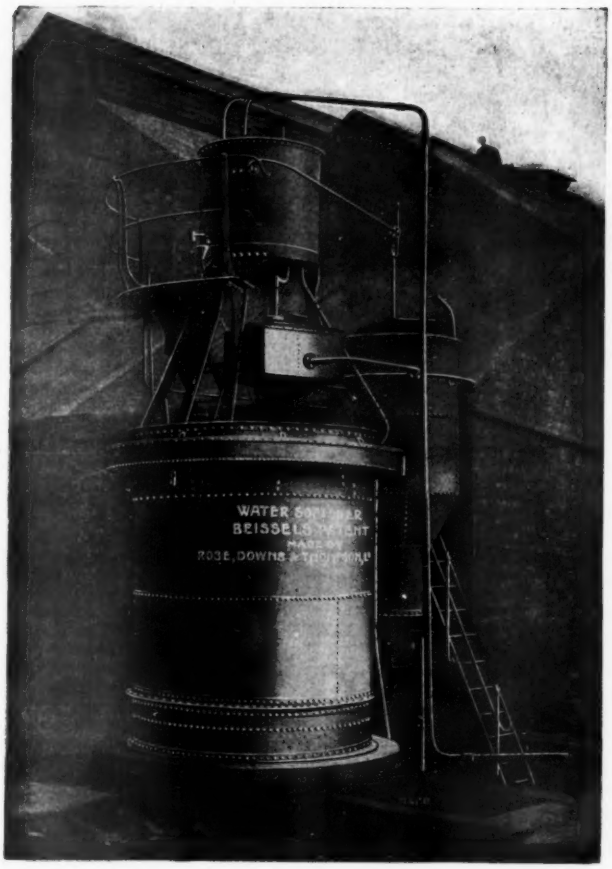
The apparatus is automatic in its action, so that there is no starting and stopping

as and when softened water is needed. The attendant can do all that is necessary for the work. The makers undertake to analyse in their special laboratory any water which is not of the desired quality for industrial or other purposes, and to arrange an apparatus which is guaranteed to effect the necessary results.

The Bruun Lowener Patent Automatic Water Softener.

ANOTHER very successful water softening plant on the market is that known as the Bruun Lowener Patent Automatic Water Softener, of which we also give an illustration.

The water to be treated is led into an automatic oscillating receiver which measures out small quantities at each tilt, and the oscillating movement is utilized to work a valve in the chemical reservoir, so that at each tip of the receiver a certain quantity of chemical reagent—viz., lime and soda ash or caustic soda—is admitted to the water.



MESSRS. ROSE, DOWNS AND THOMPSON, LTD.: THE "BEISSEL" WATER SOFTENER.

The means whereby the reagents are added to the water is an important feature in any softener, and the Bruun Lowener system leaves nothing to be desired in this respect, owing to its reliability and simplicity. For this reason the apparatus can be used where it is of the utmost importance that the water should be perfectly neutral after treatment. This is especially the case in dye-works, laundries, etc., where coloured goods are treated.

After the admixture of the chemical reagents, the water passes into the heating chamber, where it is heated by means of live or (if available) exhaust steam; and thence it flows into a settling tank, where the lime, magnesia, and other foreign matters are precipitated.

Before the water leaves the softener it passes through a filter and thence into the storage tank, in which a valve is fixed, which automatically regulates the supply of water to the softener according to requirements.

It will also be seen that this apparatus is eminently suitable for export, as it has very few working parts, and especially as it can be erected in a few hours by any unskilled mechanic.

The makers, Messrs. Lassen & Hjort, 52, Queen Victoria Street, London, E.C., inform us that they export a great number of their plants to South Africa, South America, India, etc., besides the large number they have installed in the United King-

MESSRS. LASSEN AND HJORT: THE BRUUN LOWENER WATER SOFTENER.

dom, and we further learn that altogether they now have 1,300 installations at work.

Their catalogue is very interesting, and gives an exhaustive explanation of both the chemical and mechanical parts of their process.

A Railway Paint.

A PAINT which is rapidly growing in favour in the engineering and railway world, by reason of its suitability for iron or wood work exposed to hard influences of the atmosphere, is "Ripolin," the speciality of the company bearing that name, who trade at 110, Fenchurch Street, London, E.C. The brilliancy and permanency of this pigment render it invaluable for the painting of signals, indicator boards, etc., with the result that "Ripolin" white and red are now being used with great success by a large number of railway companies, both in this country and abroad, who have adopted them after extensive trials. We are informed that tests of the red pigment made in competition with real vermilion have proved the "Ripolin" colour, which is lower in price, to be more durable. Although not essentially an anti-corrosive paint, it possesses highly anti-corrosive properties, which are secured by the fineness and purity of all ingredients used in its manufacture. In railway carriage work it has a large vogue, as by its use a saving is said to be effected over the ordinary process of painting and varnishing. Various qualities are manufactured to suit different classes of work, ranging from fine decoration to ordinary rough painting where protection is the chief object. We notice that the Ripolin Company have been awarded a gold medal at the St. Louis Exhibition.

Ice Making and Refrigerating Machinery.

THE many improvements that have been introduced during the past few years in ammonia absorption machines have brought them again into favour, and many of the largest cold stores and ice factories in the

world are now being equipped with this type, where formerly only compression machines were used. In the absorption type there is less wear and tear than in the compression system, nor is there any noise or vibration from heavy moving machinery, the only moving part being a small liquor circulating pump. The principle of the process is as follows:—

Ordinary liquor ammonia is heated by steam in a generator, the ammonia in solution being driven off and passing into a condenser, where it is cooled and liquified. From here it is allowed to escape into a cooler, where it expands back into the gaseous form, producing intense cold, the gas so formed passing into the absorber. At the same time the liquor in the generator, from which the ammonia is evaporated, is allowed to escape slowly into an absorber, which is kept cool, where it meets the gas coming from the cooler and rapidly absorbs it. A strong solution of ammonia is thus formed, which is pumped back into the generator to be again heated and used over again, the process thus going on continuously.

In practice, additions are made to the above with the object of increasing the efficiency of the apparatus. In the machines of Messrs. Ransomes & Rapier, Ltd., of Ipswich, who are well-known specialists in the manufacture of ammonia absorption plant, the ammonia gas, before entering the condenser, is made to pass through an analyser and rectifier, where it is purified.

A heat exchanger or economizer is also provided for cooling the weak liquor before it enters the absorber, and at the same time heating the strong liquor before it enters the generator.

One of their improved small machines is illustrated, from which it will be seen that it virtually consists of five cylindrical vessels fitted with a number of tubes, through which, in the case of the generator, the steam passes, and, in the condenser, absorber, exchanger, and rectifier, the condensing water. A special point to be noted in connection with the tubes is that they are in straight lengths, and any one can be taken out if found defective and a fresh one put in. In the case of a leak occurring, the header can be taken off, while the pressure of the ammonia is in the machine, and if the leak cannot be stopped, a plug may be put in the end of the tube and the machine worked without it These important advantages, together with the fact that there are practically no wearing parts, render a breakdown almost impossible.

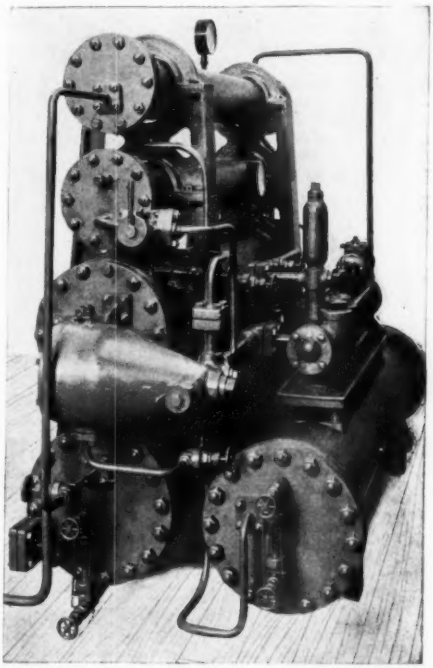
These machines, which can be worked by exhaust steam, are especially suitable for hot climates, and are equally adapted for the production of ice, for refrigerating purposes, or for marine work.

Soft Water.

THE subject of softening water for industrial purposes received, in years gone by, little or no attention, and manufacturing plants were located with a view to labour supply, cheapness of fuel, and accessibility to markets, rather than out of any consideration as to the quality of the water obtainable. Railways, in particular, have located their watering stations at places where there was an abundant supply without regard to its quality, and it is only within recent years that the losses which followed from the use of hard water in steam boilers have, owing to the keen competition of the new industrial conditions, been adequately realized.

Much the same problem has been presented to producers of almost every class of textile goods: one of the essential elements in the production of better fabrics being the supply of soft and pure water.

Modern scientific methods, however, have overcome the difficulties present, and have put within reach of steam user, railway company, and textile manufacturer alike the



MESSRS. RANSOMES AND RAPIER: AMMONIA ABSORPTION MACHINE.

KENNICOTT WATER SOFTENER CO.: WATER SOFTENER AT ALDERMASTON, G.W.R.

means of properly softening and purifying water, and, as a result, to effect an appreciable economy in working and to eliminate the evils which accrue from the use of hard or impure water.

One of the most successful systems of softening water is that of the Kennicott Water Softener Company, of 29, Great St. Helen's, London, E.C., which consists of automatically treating varying quantities of water with varying quantities of materials, always in the same proportion, in an automatic apparatus, which purifies and softens the water at a minimum cost. The apparatus for effecting this is illustrated herewith, and consists of a cylindrical steel tank surmounted by a platform upon which is the water wheel over which the hard water is first pumped on its way into the softener. The necessary receptacles for dissolving the reagents and the apparatus for automatically varying the reagents in proportion to the amount of water to be purified are placed upon the top of the tank. Centrally - located within the tank is the conical downtake or cone, and within which is the lime water saturator, placed in this position in order to protect the movable stirrer from damage by freezing. In a compartment in the top of the lime saturator tank is the mixing chamber. In this chamber the water and the necessary reagents for its purification are intimately mixed, so that the precipitation of the scale-forming material at once takes place. The water with the precipitated lime and magnesia overflows from the mixing chamber and travels slowly downward through the downtake or cone. On account of the size and shape of this downtake, the rate of flow of the water constantly decreases, so that the precipitate falls away from the water from which it was formed and collects in the conical bottom of the main settling tank, where it is periodically blown out by means of a dump valve. Upon reaching the bottom of the downtake, the water turns and rises through perforated baffle plates, and the small amount of precipitate left in the water attaches itself to these plates. When sufficient precipitate has gathered upon the plates it slides off and falls to the bottom of the tank. These plates never need to be cleaned. The water finally passes through a wood fibre filter, at the top of the apparatus, where the last particles of suspended matter are removed, and it emerges from the top of the softener and flows through the overflow pipe soft and clear, and is discharged into the storage tank without repumping.

The apparatus is continuous in its action, automatically stopping and starting with the ceasing and beginning of the flow of water

into the apparatus, which flow furnishes all the power the apparatus requires.

Every separate apparatus is built expressly for the particular needs of the water which it is to treat, after that water has been thoroughly analysed by the staff of chemists who determine the right proportion of re-agents to be introduced.

That the apparatus justifies the high claims made for it in effecting economy of coal is demonstrated by the following figures taken from records of coal consumed at a leading industrial establishments in Chicago:

With Purifier.	Without Purifier.	
April, 1900, over April, 1899..		17.43 per cent
May, 1900, over May, 1899 ..		15.65 ,,
Average for two Months ..		16.63 ,,

The Kennicott apparatus has had an extensive vogue in America, the country of its origin, and no fewer than 17 out of the 19 railway companies there using water softening apparatus having installed the Kennicott system. It is only comparatively recently that it has been introduced on this side, where already several important installations have been made, including an apparatus for the Great Western Railway Company at Aldermaston, shown in our illustration; and we are notified that an order for a 6,000 gallon machine for the Tirpentwys Black Vein Steam Coal and Coke Company at Ponytpool has just been closed. Stress must be laid upon the fact that these and all the plants designed for the United Kingdom and Colonies, with the exception of Canada, are made in this country, of British materials, and by British labour.

Finally, the company particularly emphasize that no payment is expected until the machine has gone through its trial period.

Lubrication.

SOME important improvements have been recently made in the well-known Manzel Force and Sight Feed Oil Pump, one of the numerous lubricating specialities of Messrs. Rimington Bros., Carlisle.

In the latest pattern of this pump the feeding arrangements have undergone a complete alteration. Instead of trusting to gravity, the feed is now regulated by a small plunger, which can be set to deliver from a minute drop to a perfect stream at every stroke. The difficulties of variable temperature, the variable weight of oil in the reservoir, and other conditions that interfere with a set feed where gravity is depended on, do not count with the new mechanical arrangement.

In adopting this latest improvement, new patterns have been made for all sizes of pumps, and they have also been strengthened and improved in design.

The pump is also supplied fitted with an agitating device, for feeding oil and graphite for steam cylinder lubrication. This is designed to raise the graphite from the bottom automatically and keep it thoroughly mixed with the oil. If desired, this will feed oil with anything up to 30 per cent. of graphite in it. Every engineer has his own rule for compounding this mixture, but three tablespoonfuls of graphite per day ought to keep the cylinders and valves of a 150 h.p. engine in prime condition.

Brick-Making Plant.

THOSE about to put down new plants for plastic brick making should consider the particular clay to be used and the combination of machinery most suitable.

Brick machines are often failures, owing to the preparing machinery being overlooked, a good combination of the latter ensuring at all times a regular feeding of the brick machine, which is an important point both for quality of the bricks and quantity turned out.

Messrs. Bennett & Sayer, of Derby, the well-known makers of brick-making plant, pay special attention to this point, and, if intending clients furnish them with samples of their particular clay, are prepared to recommend the machinery best adapted to it, which they are well able to do, owing to their experience as brick makers.

The saving of labour is a point to which this firm have given much consideration, with the result that they have introduced a Patent Power Pusher attached to the Brick Cutting Table, which makes a steadier and cleaner cut than the hand-worked table. It can be fitted to almost any kind of hand-worked side delivery cutting table. Another speciality is their Patent Power Cutting Table, which is mounted on an improved rising and falling base plate for adjusting to the exact level of any description of die in the shortest possible time by the means of adjusting screws. The base plate also acts as a good oil catcher beneath the table, so preventing waste of brick oil.

Packings.

THE method of securing the necessary pressure in the piston rod of an engine or pump to prevent leakage taking place differs with the different classes of packing, it being attained in some cases by setting up the gland, in others by the pressure of the steam itself, or, again, by the combination of both. Other things being equal, there would appear to be something in favour of a packing which is self-setting by reason of the fact that it is able to accommodate itself to the varying pressure from the cylinder at each point of

the stroke, and so reduce frictional losses. In the latter class, Daniell's "P.P.P." Rod Packing—a speciality of the Quaker City Rubber Company, Philadelphia, who are represented in Great Britain by Messrs. R. Trist & Co., of Coronation House, Lloyd's Avenue, E.C.—would appear to occupy a high position.

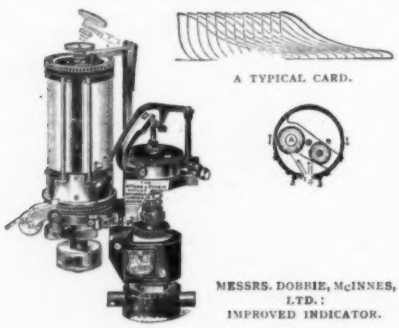
In mechanical construction this consists of two triangular-shaped wedges, backed by a yielding absorbent cushion. The pressure of this packing on the rod is secured by means of the steam pressure on the packing, or pressure from the gland, or both, forcing the cushion and wedge to the rod, the wedges being free to work backward and forward and slide over each other with the varying pressure in the cylinder. They are so shaped as to compensate for the wear made by the rod or inequalities of the rod or box. The cushion absorbs oil that may be put on the rod or fed to the box by other means, letting it down to the rod evenly and regularly, the combination making soft but very elastic packing, and, when properly applied, preventing the rod from binding or heating. The packing is prepared with the best and most approved lubricants, which will enamel the rod, filling in the scores, if any, and assisting in making the rod easy and free.

The advantages claimed for it are:—

A reduction in the power consumed, by reason of the lessened friction, which is in direct ratio to the pressures against which it is required to pack; minimized wear and tear on the rods; increased life of the packing working under these conditions, since it is not called upon to serve the purpose of a packing, except on that part of the *one* stroke of an engine when there is pressure on the gland end of a cylinder.

Indicators.

MESSRS. DOBBIE, MCINNES, LTD., of Glasgow, who have established a wide reputation for engine indicators, have recently introduced an improved apparatus to meet the requirements of winding engines, rolling mill engines, pumps., etc., in which the pressure and load varies greatly, and where a single diagram would not give a true representation of the average work done by the engine for any single operation.



A TYPICAL CARD.

MESSRS. DOBBIE, MCINNES, LTD.: IMPROVED INDICATOR.

Referring to the illustrations, the paper drum contains a cylinder *A* accommodating a roll of paper, 9 ft. long, one end of which is brought to the outside between the rollers 1 and 2, carried round the drum, and re-enters between the rollers 3 and 4 to the spindle *B*. On top of the spindle *B* there is a pinion wheel geared to the wheel on the underside of the rack *C*, and so arranged as to turn in one direction only. The drum reciprocates in the usual manner, and when the cord is pulled outwards the two pinion wheels turn with it, but on the return stroke they remain stationary, which has the effect of winding the paper from the cylinder *A* to the spindle *B*. The travel of the paper depends on the relative diameters of the two wheels, but in ordinary cases it is about half an inch. This means that the second diagram is placed half an inch in advance of the previous one, and this goes on automatically and without attention until the 9-ft. roll is exhausted. Every diagram taken is complete in itself, and can be worked out separately.

When the rack lever *C* is raised as shown in dotted lines, the paper no longer winds or unwinds, and the indicator can be used for taking ordinary single diagrams.

The small pointer shown besides the pencil arm point is an adjustable pointer for drawing a continuous atmospheric line.

A detent gear is also provided for stopping the reciprocating action of the drum at any instant without disconnecting the cord lead.

Another recent introduction of this firm is Messenger's Furnace Deformation Indicator, which space prevents us dealing with at length in this issue. It will suffice to say that the use of this instrument is invaluable to superintending engineers, marine surveyors, boiler inspectors, boiler-makers, and others.

All interested in furnaces must appreciate the great importance of obtaining a true periodical and graphic record of the circularity of the furnaces. It is a specially serviceable part of a ship's outfit, and should be specified with the equipment of all vessels having circular furnaces, and more especially with those having forced draught. When so supplied, the superintendent could require furnace diagrams to be taken, like indicator diagrams, and in that way ascertain by a glance if any distortion had taken place since the previous diagram was taken, no matter from what cause, and be enabled to deal with the defect at its commencement.